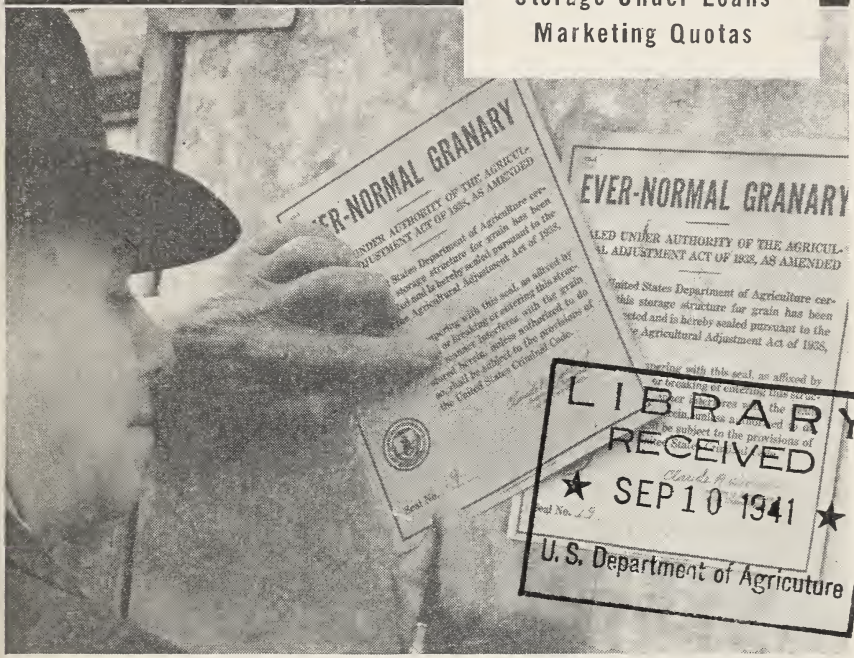
G-106
Issued June 1941

Wheat Storage on the Farm and in the Ever-Normal Granary

Bins and Granaries
Storage Under Loans
Marketing Quotas



The Ever-Normal Granary

Holds surplus for short years
Protects farm income
Strengthens national defense
Helps balance production
and conserve soil

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Adjustment Administration
Washington, D. C.

THE EVER-NORMAL GRANARY IDEA

The Ever-Normal Granary represents an idea that goes back to ancient times—the idea of storing supplies in years of abundance for use in years of scarcity. In its modern application, whether scarcity is brought about by crop failure, drought, or an emergency situation caused by the economic dislocations of war, the storage of food and other farm products under the orderly plan of the Ever-Normal Granary provides security against want in any eventuality.

In recent years, when the uncertainties of weather have at times resulted in extreme fluctuations in supplies from year to year and world markets for our products have been upset by the disturbances of war, the Ever-Normal Granary has also emerged as a bulwark of national defense through protection of our productive resources and establishment of abundant reserves.

In a broad sense, the Ever-Normal Granary is a principle of agricultural planning to which all the programs of the Department of Agriculture are contributing. It stands for maintenance of our soil fertility, and protection of farm income, as well as orderly storage of reserve supplies; and toward these objectives millions of farmers are now working under our national farm program. Soil conservation activities, acreage allotments, marketing quotas, loans, crop insurance for wheat, and research and technical programs in all phases of agriculture are in line with the Ever-Normal Granary plan.

As we grow in experience with the plan, it should result in more efficient farm management, in added assurance to consumers of abundant supplies at all times, and in a substantial contribution to the economic security of those engaged in marketing and processing farm products. Of direct interest to grain producers, it should bring about a great improvement in the storage facilities on farms. As the important steps in providing practical and safe storage buildings to care for and prevent the deterioration of farm-stored wheat can only be taken by farmers themselves, it may readily be seen that farm cooperation in carrying out the storage requirements outlined in this bulletin is necessary to give maximum effect to the Ever-Normal Granary idea.

Claude R. Wickard

Secretary of Agriculture.

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WHEAT STORAGE ON THE FARM AND IN THE EVER-NORMAL GRANARY

This bulletin was prepared by representatives of the Bureau of Agricultural Chemistry and Engineering, Bureau of Entomology and Plant Quarantine, Agricultural Marketing Service, and Agricultural Adjustment Administration, in the United States Department of Agriculture, with the assistance of engineers and entomologists of the agricultural colleges of States in the wheat-growing areas. It brings up to date the information contained in the bulletin, 38–Wheat–1, "Wheat Storage in the Ever-Normal Granary," issued by the AAA in May 1938.

1. THE EVER-NORMAL GRANARY PROGRAM FOR WHEAT

PROVISIONS OF AGRICULTURAL ADJUSTMENT ACT OF 1938

Definite provisions for building up an Ever-Normal Granary for wheat are included in the Agricultural Adjustment Act of 1938.

One of these is the provision for acreage allotments. Through the use of allotments, and with the assistance of conservation and parity payments, farmers cooperating in the AAA program adjust production in a way that assures abundant supplies, avoiding at the same time wasteful use of their land. Acreage allotments for wheat, as for other crops, leave more acres for soil-conserving uses, thus making possible the building up of soil fertility.

When supplies of wheat become excessive, marketing quotas may be voted into effect by producers as a means of making acreage allotments more effective, stabilizing production, and preventing soil depletion. When in effect, quotas assure supplies large enough to take care of normal needs plus an abundant reserve as a protection against future shortage. Loans and crop insurance for wheat are closely related features of the program. Loans help hold surplus wheat in orderly storage, stabilize wheat prices, and protect farm income when the surplus gets too big; crop insurance protects the wheat producer against unavoidable crop losses.

The use of allotments and quotas, storage of wheat under loans, and maintenance of an insurance reserve of wheat—all these things, plus other related activities under the national farm program, are working together to maintain our Ever-Normal Granary for wheat. Local administration of the plan is carried out by the AAA through its elected county and community committees of farmers.

WHEAT STORAGE LOANS

The storage of wheat under loans plays an important part in the Ever-Normal Granary plan, protecting the producer's income while he cooperates with other farmers in a program to stabilize production and maintain soil fertility.

Under the Agricultural Adjustment Act of 1938, wheat loans at rates from 52 to 75 percent of parity were made available when the farm price of wheat fell below 52 percent of parity or the July crop estimate exceeded a normal year's domestic consumption and exports.

However, an amendment to the act, approved May 26, 1941, authorizes loans on the 1941 wheat crop at 85 percent of parity. Only farmers who have not exceeded their AAA wheat acreage allotments may receive such loans, but it is provided that, whenever marketing quotas for wheat are in effect, loans at a lower rate may be received by noncooperators on part of their production.

USE OF MARKETING QUOTAS

Marketing quotas may be brought into operation by wheat producers when the total supply of wheat exceeds a normal year's domestic consumption, plus exports, by more than 35 percent. Approval by a two-thirds majority of the wheat farmers voting in a national referendum is necessary to make quotas effective. With quotas in effect, loans are available on the entire production of producers who have not exceeded their wheat acreage allotments, or such producers may sell their entire production without penalty. Loans are available to producers who have exceeded their acreage allotments on that part of their production which is in excess of their marketing quotas, but at a lower rate than that established for cooperators; penalties are provided on sales of wheat in excess of such producers' quotas. Marketing quotas, backed by loans, are designed to give wheat producers a cooperative means of protecting their industry.

2. STORAGE OF WHEAT UNDER LOANS

GOOD WHEAT, PROPERLY STORED, IS REQUIRED SECURITY

The loan program provides that the stored wheat shall be the only security the Government has for its loan. Hence it is essential to the success of the Ever-Normal Granary that only good-quality wheat be stored and that it be placed in bins or granaries where it will not be subject to losses in quantity or to damage from moisture, insects, rodents, or other sources.

Approval of structures is under the direction of the county committees of the Agricultural Adjustment Administration.

WHAT IS GOOD WHEAT?

Good wheat must be dry, undamaged, plump, and clean, but the importance of dryness cannot be overemphasized. **Dry wheat** may be stored successfully even though it is damaged and not plump and clean. The dryer the wheat the longer it can be stored, the less danger of damage by insects, and the less important that it be clean and plump. If wheat contains 8 percent moisture or less, common insects cannot multiply in it, and the changes which result in loss of germination and quality of the wheat take place very slowly.

Any practice that will result in reducing the moisture content of wheat before it is stored should be used. Wheat dries rapidly when exposed to dry air in thin layers, but the moisture content of wheat in bins changes very little except at the upper surfaces where it is exposed to air.

Unclean wheat is more likely to be infested with insects, and control is difficult because the penetration of fumigants is uneven. Garlic, smut, or any material which will impart an odor to the wheat, or ergot

or any other poisonous substance, will lower the grade and value. Rye or other grain which cannot readily be removed is objectionable.

MEASURES OF QUALITY OF WHEAT

The quality of wheat upon which loans are made in the Ever-Normal Granary program is determined by the use of the Official Grain Standards of the United States. A summary of these standards is given in the appendix, page 48. Not all grades are eligible collateral for loans, and limits on moisture content for wheat under loan are lower than provided in the standards. This stricter requirement for farm-stored wheat is necessary because wheat in approved warehouses is under constant observation, equipment for cooling and conditioning is available, and the storage company is bonded to deliver the same grade of wheat that it received.

GRAIN MUST BE ACCESSIBLE FOR SAMPLING

When a loan is to be requested, the wheat will have to be sampled properly. The wheat must be accessible for probing throughout the entire lot of grain, so that a correct and representative sample can be obtained for grading. If the wheat is not more than 6 feet deep and there is 2½ feet headroom, there will be no sampling difficulty. If the bin has a greater depth of wheat or insufficient headroom, it may be necessary to move sufficient wheat to permit the sampler to probe all portions of the lot.

3. REGIONAL PROBLEMS IN STORING WHEAT

The principal wheat-producing areas of the United States are shown in figure 1. Because of the different classes of wheat grown and the various climatic conditions, the storage problems in each area differ.

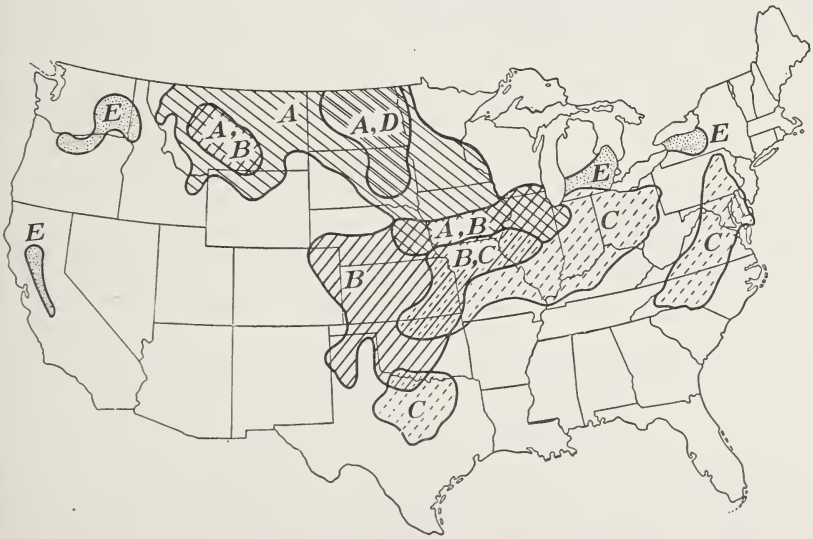

FIGURE 1.—Principal wheat-producing areas of the United States: *A*, Hard red spring wheat area; *B*, hard red winter wheat area; *C*, soft red winter wheat area; *D*, durum wheat area; *E*, white wheat area.

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HARD RED SPRING AND DURUM WHEAT AREAS

In the area where most of the hard red spring and durum wheats are grown, the weather is usually favorable for drying wheat at harvesttime, and high temperature periods are short enough to prevent serious insect problems if wheat is well-stored. As snow may be blown into bins in this area, bin construction must be tight to avoid this hazard (fig. 2).

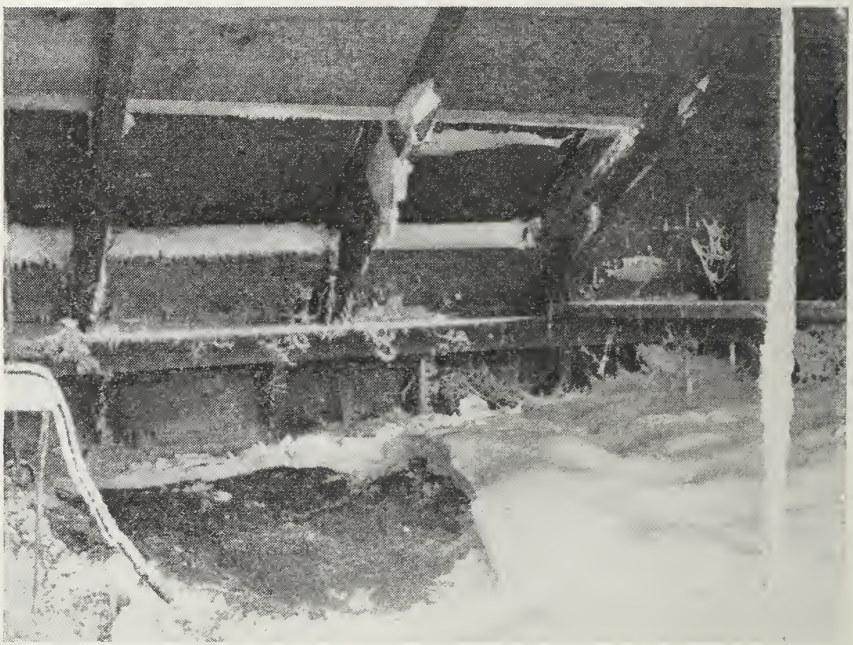

FIGURE 2.—Snow blown into bin in North Dakota in one blizzard; part of snow removed to show depth. This bin excluded rain and was probably tighter under the eaves than the ordinary farm bin.

As the temperature of the wheat is usually not high at harvesttime and because a long period of high temperatures does not usually follow harvest, it is often possible to store wheat with a moisture content up to 14 percent or 14½ percent from harvesttime to the following summer without damage. If the wheat is to be stored for a year or more, it should not contain this amount of moisture. Long-time storage of wheat which is frosted, sprouted, or combined or threshed green should not be attempted. Sound, dry wheat in good bins has often been stored without appreciable loss for several years in this area.

HARD RED WINTER WHEAT AREA

In the Southern Great Plains area where most of the hard red winter wheat is produced, weather conditions are favorable for drying wheat at harvesttime in most seasons. High temperatures at harvesttime and during the summer and fall cause high-moisture wheat to become dam-

aged quickly. Temperatures are more favorable to insects in this area than in the spring wheat area. Dry wheat, tight bins, and fumigation when necessary, are insurance against damage from this cause.

The best evidence that wheat can be stored on farms for several years without loss is the record of such storage in the past. Producers in this area can be in a position to reduce price fluctuations and storage and handling costs if they carry surpluses of sound, dry wheat in good bins and protect it properly against insects until the supply is needed.

SOFT RED WINTER WHEAT AREA

Weather conditions in most of this area at harvesttime are not as dry as in other areas but as most of the wheat of this class is not grown on extensive acreages it can usually be harvested and threshed under conditions favorable for drying. In the area around the Great Lakes it is often difficult to dry wheat to 13-percent moisture content, but, because temperatures are not high and the wheat is more likely to be stored in small quantities, a slightly higher moisture content may not cause storage difficulties during the fall and winter following harvest. For long-time storage in the Great Lakes region, a moisture content of 13 percent or below is recommended. Bins should be tight to prevent dry wheat from absorbing moisture from the air and also to make effective fumigation possible when necessary. Ventilator openings must be provided with covers so that they can be closed in damp weather or for fumigation.

In the more southern part of the area constant protection from insects is needed and storage must be under conditions which will permit such protection. The milling of much of this type of wheat is done in mills close to or in localities where the wheat is produced, and the storage of this class of wheat for long periods is not common in the southern part of the area, but, where proper precautions are taken, storage can be successful in the greater part of the area.

Most soft winter wheat growers can store wheat economically and safely under conditions which meet the requirements of the loan program.

WHITE WHEAT AREA

The Pacific Coast areas in which white wheats are customarily grown are generally dry, but where white wheats are grown in the Great Lakes area it is more humid than in the hard red spring wheat area while temperature conditions are similar. The relationship of moisture and insect problems to the length of the storage period is similar.

In all of the wheat-producing areas, damp wheat may occasionally be harvested because of wet weather. For this reason it may be practical for the farmer to provide some ventilated storage space for damp wheat. Ventilation systems are discussed on page 25.

4. REQUIREMENTS FOR BINS AND GRANARIES

Types of bins and granaries which are satisfactory for farm storage of wheat, and faults that should be remedied before wheat is stored, are described in the following sections. Buildings which

do not meet requirements can often be adapted for use as temporary bins or repaired at reasonable cost. The bin or granary used for farm storage of wheat should be a substantial and permanent structure which will:

1. Hold the wheat without loss of quantity.
2. Protect the wheat against weather conditions which may cause deterioration in quality.
3. Afford reasonable protection against thieves, rodents, birds, poultry, and insects.
4. Permit effective fumigation for the destruction of insects.
5. Provide reasonable safety from fire and wind.
6. Require forcible breaking in order to be entered after sealing.

LOCATION AND SURROUNDINGS[1]

The bin or granary should be in or near the farmstead as protection against loss by theft. It should be located on a well-drained site and safe from damage by surface water. In no case should bins be located on river or creek bottom land subject to floods.

The granary should be far enough from other buildings and from stacks of straw, hay, etc., to reduce fire danger. A distance of 50 feet at right angles to the prevailing winds is considered reasonable protection but distances up to 100 feet are far better and should be used where possible. The site should be kept free from junk, trash, and weeds which constitute fire hazards and harbor rats and mice.

The location of bins in other buildings, especially in machinery sheds, is permissible if ordinary precautions in construction and in protection against rodents and insects are observed. The protection from the sun provided by the building may result in a lower temperature in the bin during the summer and therefore in better storage.

TYPES OF BINS AND GRANARIES

In selecting bin space or when considering new construction for wheat storage, the following facts about most common types should be kept in mind.

Single bins.—A single bin structure that can be placed in a safe location out of the way of ordinary operations will provide satisfactory storage for wheat that is dry and in good condition when stored, but does not provide space where wheat can be conditioned if trouble develops. However, the single bin may be more easily fumigated and is less likely to be reinfested with insects than is an individual bin in a large granary or a bin in another building.

Movable wooden bins (fig. 3) and steel bins are common kinds of single bins in general use. These should be placed on good foundations or footings as described on page 12 and should be tight enough to prevent snow from drifting in at the eaves, manhole covers, and ventilators (fig. 2). They are usually more exposed to stormy winds because of being separate from other buildings and therefore should be anchored well.

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[1] Suggestions on building arrangement may be found in Farmers' Bulletin 1132, Planning the Farmstead.

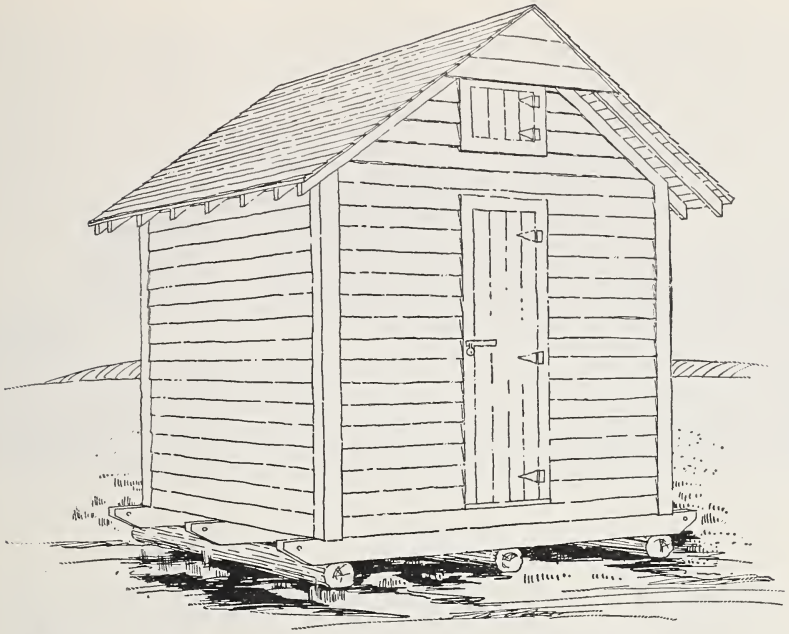

FIGURE 3.—A movable wood bin, capacity 500 bushels. Note skids resting on logs. Design No. 5530. Same style but 1,000-bushel capacity, Design No. 5531.[2]

The structural requirements and the care of steel bins are discussed on page 22.

Old boxcars make suitable grain storages if set on well-constructed foundations (fig. 4).

FIGURE 4.—An old boxcar makes a substantial farm storage, with a total capacity of about 2,000 bushels. Note concrete foundations and good clearance above ground. A door for the filling opening is needed. If the space between the doors were left empty, it would be easier to move the grain in case of heating or other trouble.

[2] See page 23, How To Order Plans.

FIGURE 5.—Granary with several bins. Note heavy foundation and provision for emptying large part of grain by gravity through spouts built into side of granary.

FIGURE 6.—A farm granary 26 by 38 by 12 feet, balloon framing. Bins are filled by means of an inside cup elevator, driven by a portable engine. Windows over the driveway door light the interior, permitting inside work during bad weather.

Granaries with two or more bins.—Granaries with several bins and a working floor on a driveway have several advantages over isolated bins, since grain in such granaries can be moved, cleaned, or spread out in thin layers if necessary to cool the grain with a not unusual amount of labor, and in unfavorable weather. A granary divided into several bins permits more flexibility in sealing and releasing wheat under loan than if only one large bin is available (fig. 5). A power-operated elevator is a great convenience in filling and in moving grain to condition it. For types of elevator-equipped buildings see figures 6 and 7.

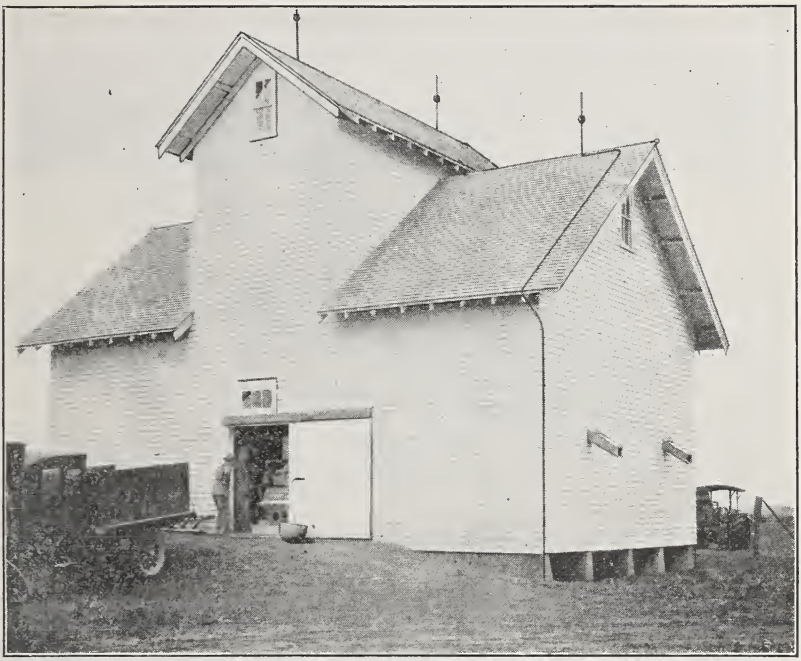

FIGURE 7.—A well-equipped farm granary with facilities for cleaning and elevating the grain. The grain spouts decrease labor cost in handling grain. Lightning rods protect the building and contents. Note high foundation.

Combined corncribs and granaries.—The overhead bins in large corncribs provide good storage space for wheat, except in the southern States, where insects in the ear corn in cribs are likely to attack the stored grain (fig. 8). With either built-in or portable elevators, wheat can be taken from the overhead bins readily and put back into other bins.

FIGURE 8.—This type of combined crib and granary provides good storage for wheat or other grain in the bins over the driveway.

Farm elevators.—On large grain-producing farms in some sections of the country a type of storage structure called an "elevator" is used where the handling costs must be kept low (fig. 9). Because of the deep bins in this type, the walls are built up of 2-inch lumber laid flat and spiked together.

FIGURE 9.—Farm grain elevator of crib construction, suitable for storing 6,000 to 10,000 bushels of wheat. The storage contains 10 bins with inside dump and elevator and space for cleaning and grinding machinery. Design No. 5532.

Bins in barns.—Bins in barns are most common in the northern part of the soft winter wheat area and to some extent in the eastern part of the hard red winter wheat area where considerable livestock are raised. While this type of storage involves greater risk of damage by insects harbored in waste feeds, experience has shown that the type of storage has been practical during the past few years in the above areas. The grain is ordinarily not piled deeper than 4 or 5 feet and the added protection from the sun in the summer has resulted in maintaining lower temperatures of the wheat. This, together with the

fact that average temperatures are lower in these areas than in those farther west and south, is probably one of the main reasons why it

FIGURE 10.—Type of barn storage most nearly meeting requirements. Barn is well constructed and in well-drained location. The bin is completely enclosed with strong tight walls, floor, and ceiling; surroundings are clean.

FIGURE 11.—Bin in barn not acceptable for wheat under loan because of unprotected condition and likelihood of damage by insects, barn odors, moisture, rats, and mice. It would be impractical to fumigate a bin like this.

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has been possible to store wheat with higher moisture in such bins in the soft winter wheat area.

Frequent inspection and sampling of the grain for insects will be necessary and fumigation is almost certain to be required to protect the grain. Fire hazard and possible damage from rodents are objections to this type of storage. There is also the possibility that moisture or barn odors may be absorbed by the wheat. Figures 10 and 11 illustrate types of barn storage, both desirable and undesirable.

Bins in machinery sheds.—Figure 12 shows a popular type of machinery shed used in West Central States in which wheat is often

FIGURE 12.—Round-roof machine shed of type used for temporary grain storage in West Central States. Individual bins with floors should be constructed for grain. Design No. 5145 (2 sheets).

stored. Individual bins are erected along the side walls with driveway space through the center. A large amount of storage can be obtained in this manner.

STRUCTURAL REQUIREMENTS

Foundations.—The foundation should have footings large enough to prevent the bin from settling. One square foot of surface bearing on the ground for each 60 bushels of wheat is satisfactory on most soils. Additional area for bearing can be obtained by making the footing wider at the bottom, as shown in figure 13. The foundation should extend deep enough into the ground to give stability, provide protection against freezing and prevent undermining by water, rodents, and livestock. Table 1 shows the recommended depths of foundations for grain bins in the different regions in the United States to give reasonable protection against heaving by freezing. In no case should the depth be less than a foot to prevent rodents from burrowing underneath.

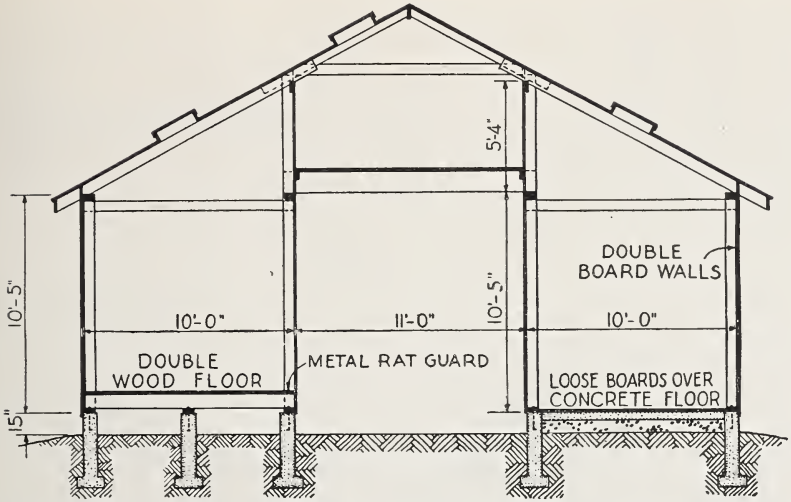

FIGURE 13.—Cross section of granary design, showing wide footings, in connection with both wood and concrete floors. Note anchor bolts, studs lapping and spiked to wood joists, and double-boarded wall with no inside lining.

Foundations should be high enough above ground level to give good air circulation under wood floors and to discourage rats and gophers from building their burrows up against them. Fifteen to eighteen inches above the ground is a good height for the foundation.

TABLE 1.—*Recommended depths of foundations for granaries* [1]

State	Depth to bottom of footing	Remarks
	Inches	
Alabama	12	Reinforce footing where necessary.
California	12–18	
Idaho	18	
Illinois	12–18	Reinforcement advised.
Indiana	18–24	
Kansas	24	Reinforce—heavy footings desirable.
Kentucky	18–24	
Michigan	24	
Minnesota	18	
Missouri	18	
Nebraska	18	Guard against roof water and rooting animals.
New Jersey	24–30	Reinforce footings.
New York	36	
North Carolina	30–36	
North Dakota	18	Reinforcement advised.
Ohio	18	Do.
Oklahoma	18	
Oregon	24	
South Dakota	18	Use continuous foundation under frame buildings.
Vermont	12	Varies widely—carry to firm soil.
Virginia	24	

[1] A compilation of data furnished by State colleges. These depths are considered sufficient to prevent damage by frost but are not the total depths to which frost penetrates. Soil conditions at the stated depths should be noted; if not firm, footings should be made wider, reinforced, or carried deeper than indicated in the table.

Permanent foundations should be built of masonry, preferably concrete. In continuous foundations, two ⅜-inch reinforcing bars placed in the bottom and the top add considerably to the strength and also aid in preventing cracking of the concrete. One-half inch anchor bolts 16 inches long and about 6′ feet apart should be spaced in continuous foundations to anchor the bin against strong winds.

FIGURE 14.—Concrete blocks used as foundation for combined corncrib and granary. Note soil eroded away from footings.

Loose stone foundations are unsteady and often make ideal harbors for rats. Stone should be laid up with mortar and all spaces or cracks well filled. (Fig. 5.)

Semipermanent or temporary foundations are being used rather extensively for small- and medium-sized bins, and have in general given satisfactory service. Figure 14 shows a wood combined crib and granary placed on concrete blocks. If a large enough number of blocks are used to give sufficient bearing and if the floor is high enough above ground, blocks are satisfactory. Figures 15 to 17 show

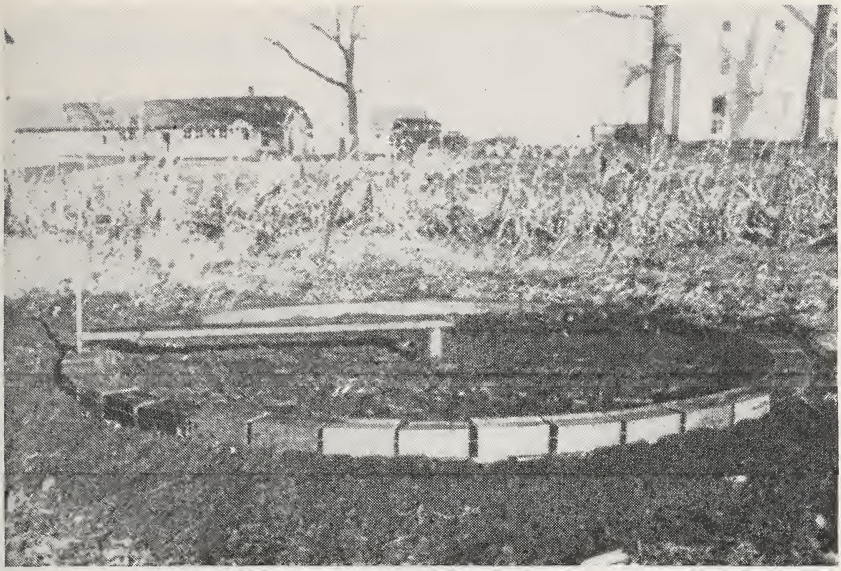

FIGURE 15.—First step in construction of foundation for round steel bin. Concrete blocks or load-bearing tile laid in trench, on firm soil, and leveled by means of carpenter's level on swinging radius bar. Note steel wire to hold blocks in position.

the installation of a foundation and gravel fill for a steel bin. The type of foundation shown gives very satisfactory service if the blocks are placed on firm ground and are placed level so as to provide uni-

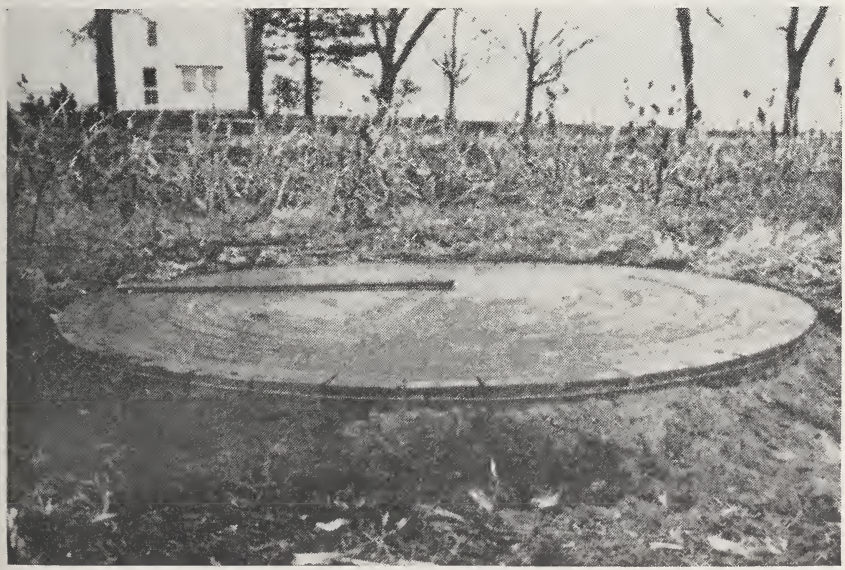

FIGURE 16.—Space inside block circle filled with sand or gravel and leveled with swinging bar. Gravel in center of circle approximately 4 inches higher than tile, to provide for settling and for drainage.

form bearing for the bin. Either concrete blocks or load-bearing tile should be used. If the ground is sloping, more than one layer of blocks must be used on the low side.

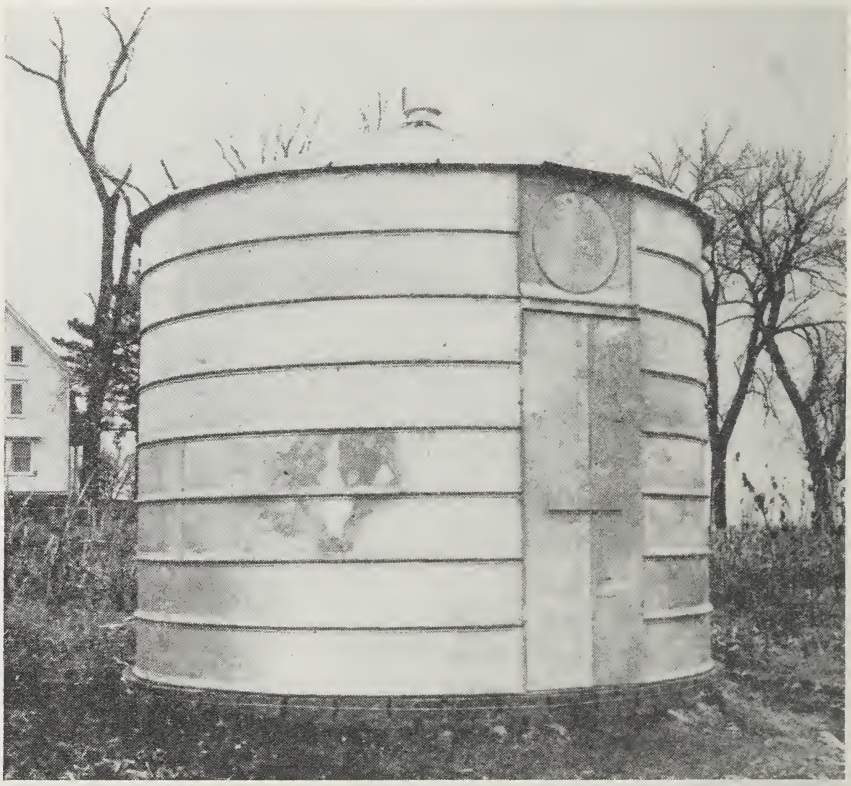

FIGURE 17.—Steel bin in place on foundation. Bottom side of floor should be painted with asphalt before being laid on gravel.

Floors.—Floors and joists must not be loaded beyond their weight-carrying capacity. Table 2 shows the depth to which wheat may ordinarily be safely stored on wood joists of common sizes with ordinary spans and spacings. In some cases it may be more economical to shorten the span, thus reducing the size of joist necessary, by adding another foundation pier for joist support. A joist which is split near the center is weakened considerably. Similar reduction in strength may be caused by large knots, especially if they are near the lower edge of the joist. Joists with such defects should not be used. Flooring and joists should be inspected carefully for termite damage [3] and decay.

[3] For further information see Leaflet 101, Injury to Buildings by Termites.

TABLE 2.[1]—*Safe depth of wheat in bins with joists of common sizes and spans, with 2 and 3 supports, for 24-, 16-, and 12-inch spacings*

A—JOISTS SUPPORTED AT ENDS ONLY

24-INCH SPACING

Size of joist (inches)	Depth of wheat for—			
	6-foot joist	8-foot joist	9-foot joist	10-foot joist
	Feet	*Feet*	*Feet*	*Feet*
2 by 6	3			
2 by 8	4½	3		
2 by 10	6	4	3½	3
2 by 12	8	5	4½	4

16-INCH SPACING

2 by 6	4½			
2 by 8	6½	4½	3½	3
2 by 10	9½	7	5½	4½
2 by 12	12	8	7	6

12-INCH SPACING

2 by 6	6			
2 by 8	9	6	5	
2 by 10	12	8½	7½	6
2 by 12	16	11	9½	8

B—JOISTS SUPPORTED AT EACH END AND AT CENTER

24-INCH SPACING

2 by 6	4½	3¼		
2 by 8	6	4¼	3½	
2 by 10	8	5½	4¼	3½
2 by 12	10¼	6¾	5¼	4¼

16-INCH SPACING

2 by 4	4¼	3		
2 by 6	7	4¾	3¾	3¼
2 by 8	9¾	6½	5¼	4¼
2 by 10	13¼	8¾	6½	5½
2 by 12	16¾	11½	8	6½

12-INCH SPACING

2 by 4	6	4¼		
2 by 6	9¾	6½	5¼	4¼
2 by 8	14¼	9¼	7	5¾
2 by 10	19¼	12½	9	7¼
2 by 12	24¼	15¾	11½	9

[1] This table is based on the ordinary commercial sizes of lumber. If the joists are full-size rather than nominal, the depth of grain can be increased one-third. If soft, lightweight lumber such as cottonwood is used, the depth of grain should be reduced one-third. The joists should be bridged to distribute the load and to prevent twisting and turning.

A tight floor is required to hold grain and prevent escape of fumigating gases. Small holes may be covered with sheet metal nailed in place. Wood floors with cracks should be covered with tight floor-

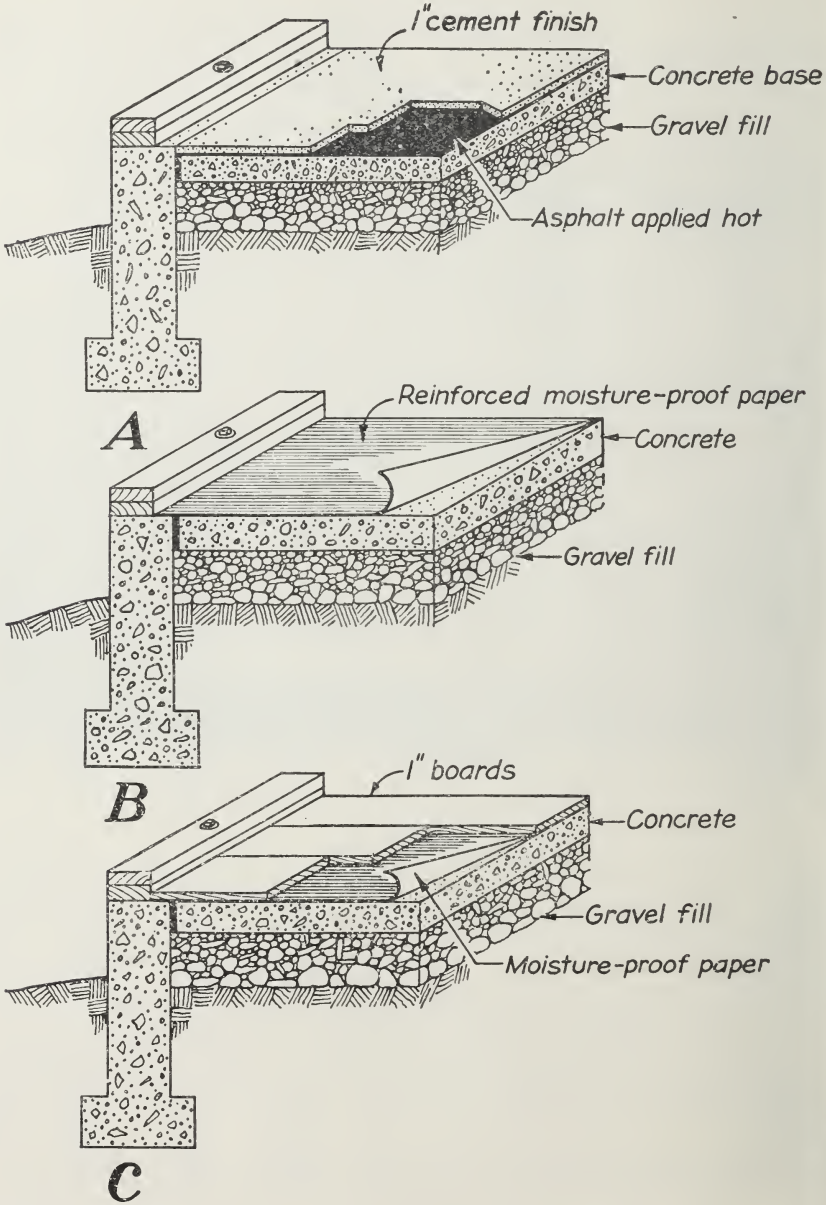

FIGURE 18.—Methods of constructing and treating concrete floors to reduce spoilage of wheat: *A*, Two-course concrete floor, with layer of asphalt between courses; *B*, moisture-proof kraft paper over concrete; *C*, loose boards over concrete.

ing, with paper between the two layers. Sections of the floor which have been eaten by rats should be covered with sheet metal or hardware cloth before the new flooring is laid.[4] Where cracks are small, covering the floor with kraft paper may be satisfactory. Paper or other material with an objectionable odor should not be used because wheat absorbs odors and these may cause the wheat to grade lower.

Concrete floors in bins which are to be used for long-time wheat storage should not be less than 8 inches above ground level at any point around the bin, and underlaid with hollow tile or with at least 6 inches of coarse gravel.

Where the ground around the bin is often moist, spoilage of wheat near the concrete can be reduced by covering the floor with a layer of moisture-proof kraft paper, by painting the concrete when dry with two coats of asphalt-aluminum paint, or by laying loose boards over the concrete.

In the case of new concrete floors the moisture barrier may be provided by allowing the 3-inch base to set and dry, then mopping it with enough hot asphalt so that the final surface has a high gloss and is smooth, and finally applying a 1-inch cement-mortar finish. Several of these methods are shown in figure 18.

In the more humid regions, concrete floors that are less than 8 inches above ground should be floored with matched wood boards laid on 2- by 2-inch or 2- by 4-inch wood nailing strips. The space between the boards and concrete should be ventilated to the outside and screened to keep out rats and mice, or high enough to admit cats.

Bins with metal floors may be placed on a 5-inch gravel fill retained by masonry blocks as was described on page 15, or they may be set on a tight deck of boards or planks. The deck should not be larger than the bin floor so that melted snow or rain will not have an opportunity to collect and run into the bin. A coat of asphalt roofing paint should be applied to the underside of the sheet metal floor as added protection against corrosion of the metal, if the bin is set directly on a gravel fill. Floors of steel bins should be at least 8 inches above the ground surface. In regions of deep snows they should be higher to prevent entrance of water from melting snow. It is considered good practice to slope the floor slightly toward the wall.

Walls.—Walls of wheat bins must be strong enough to withstand the lateral pressure of the grain. The size and the spacing of studs affect the strength of the walls. Table 3 shows the safe depths of wheat for common sizes and spacing of studs. The bottom of the studs must be securely fastened to the joists or otherwise securely fastened to resist the outward pressure of the wheat.

In bins with walls which are too weak to permit being filled to full height, cross ties of wires or rods may be installed. With such tie-rods, 4- by 4-inch or larger stays are placed around the outside of the bin as shown in figure 19. Cross tieings in the form of boards and cross braces often are not satisfactory because they are not fastened securely enough at the ends with nails or common bolts.

[4] Farmers' Bulletin 1638, Ratproofing Buildings and Premises, gives further information on this subject.

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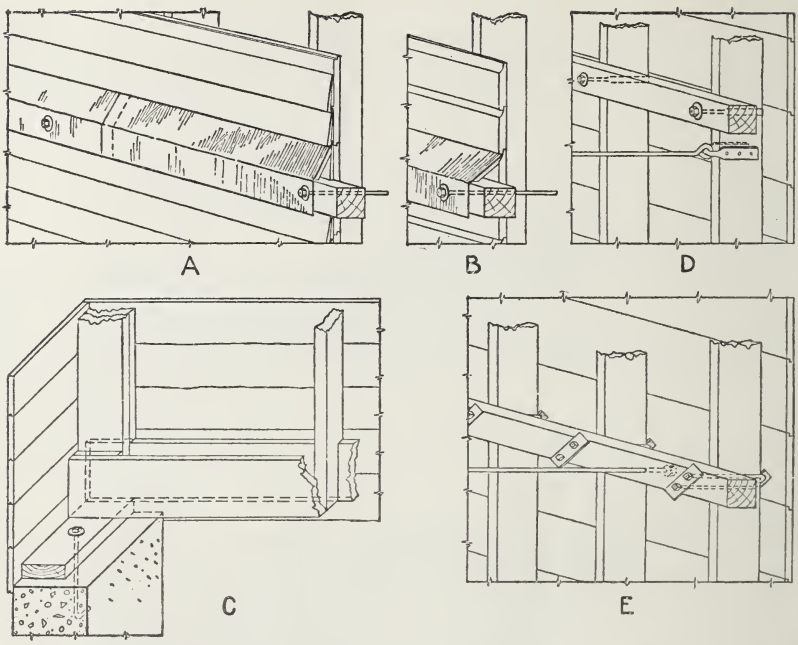

FIGURE 19.—Methods of reinforcing wall for greater depth of wheat than shown in table 3, and bin wall details: *A*, Exterior stay timber with flashing on double-boarded wall; *B*, flashing with single boarding; *C*, framing of studs, joists, and sill at corner of a granary; *D*, stay timber secured with wagon box bolts, the tie rods being secured to studs; *E*, inside stay timber secured to studs with U-bolts, the tie rods extending through the timber.

TABLE 3.[1]—*Safe depth of wheat in bins with studs of common sizes and spacings*

Size of stud (inches)	Spacing center to center	Depth of bin	Depth of wheat	Size of studs (inches)	Spacing center to center	Depth of bin	Depth of wheat
	Inches	*Feet*	*Feet*		*Inches*	*Feet*	*Feet*
2 by 4	24	8	4	2 by 6	24	8	7
2 by 4	16	8	6	2 by 6	16	10	8
2 by 4	12	8	7	2 by 6	12	10	9

[1] This table is based on the ordinary commercial sizes of lumber. If the studs are full-size rather than nominal, the depth of grain can be increased one-third. If large knots occur in any of the studs or if the lumber is soft and lightweight, ties should be used across the bin. Studs should be well fastened to the floor system.

Bin walls must be tight. Preferred construction for wood frame bins calls for two thicknesses of material on the outside of the studs, with a layer of waterproof paper between and no lining on the inside of the studs (fig. 20). Sheathing may be of plain boards, shiplap, matched boards, or ⅜-inch plywood. Sheathing must be well nailed; use two 10-penny nails per board for the bottom half of bins not more than 10 feet deep, or 6-penny nails spaced 3 inches with plywood. For the upper half of the bin use two 8-penny nails per board, or space 6-penny nails 4 to 6 inches for plywood. Lay waterproof paper over

sheathing and cover with one of the following: (1) Either vertical or horizontal siding, (2) shingles, or (3) galvanized sheet metal.

All loose boards in old bins should be renailed and all defects in the wall repaired before bins are filled. Single walls of plain boards

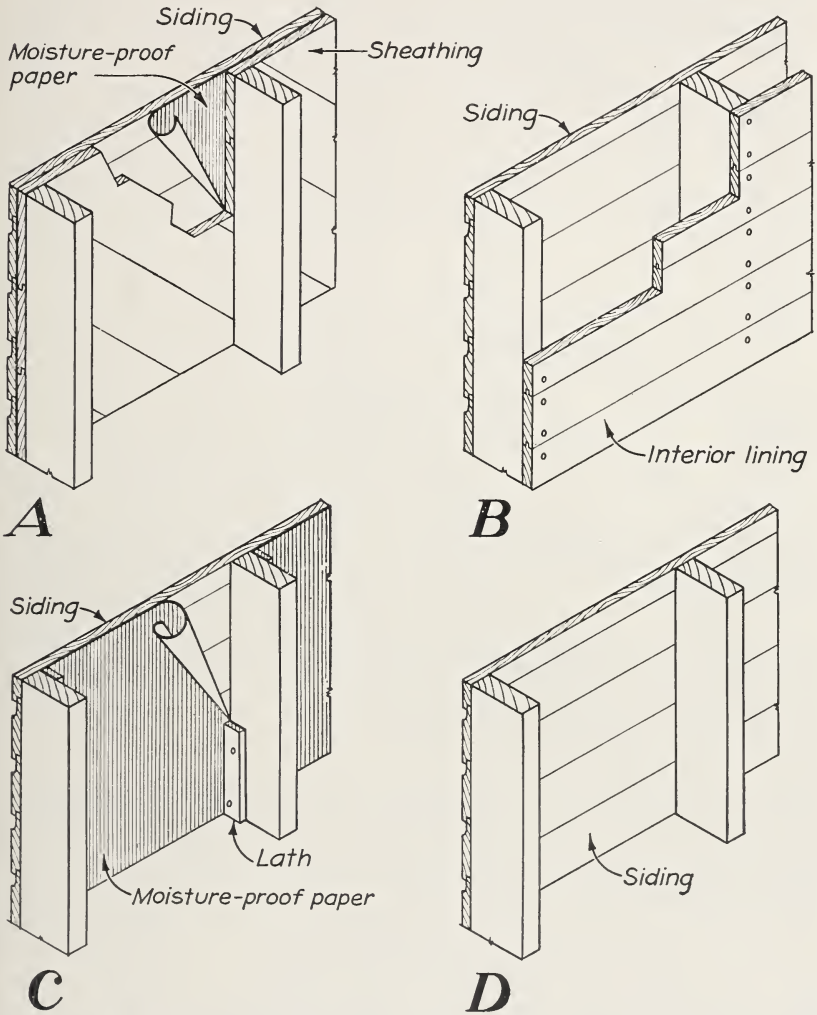

FIGURE 20.—Methods of wall construction for wood bins: *A*, Wood sheathing and siding with moisture-proof paper between; *B*, double wall, siding on outside of studs, matched boards on inside; *C*, siding with moisture-proof paper lining; *D*, siding without lining.

may be made tight by applying building paper and an additional layer of siding, or by lining the inside with matched boards or plywood. The lining should start 4 inches above the floor to leave space for cleaning out grains that may run or accumulate between the wall and lining. Single walls that are otherwise structurally sound can

be made tight with less expense by lining the inside of the wall between the studs with a duplex reinforced kraft paper or one similar to it. It may be securely held in place by wood lath. This is to make the wall tight against rain and for fumigation purposes.

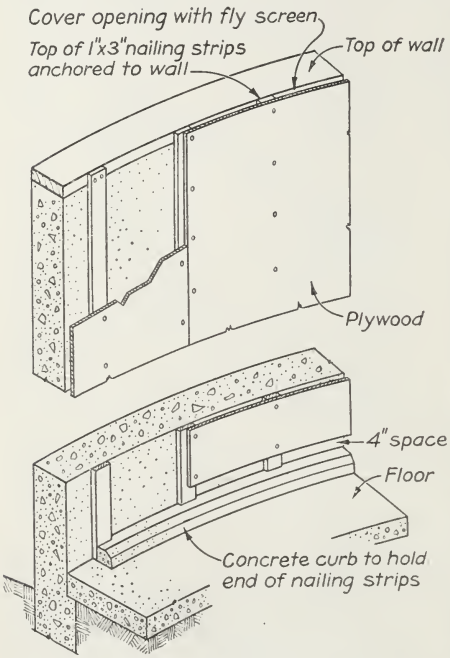

FIGURE 21.—Method of furring and lining masonry walls. Where the walls leak, honeycomb spots and holes should be plastered with 1:2 portland cement mortar and given 2 coats of tar or asphalt inside before placing furring.

Steel walls should be examined, missing bolts replaced, and all joints drawn tight. Lead washers should be used under the bolt heads. Any perforations or faulty joints that may leak should be sealed with calking compound or other suitable waterproofing material. Joints in steel bin walls that are close-fitting and have all bolts drawn up tight do not leak under ordinary conditions. Additional protection from moisture can be obtained by sealing the junction of the wall and floor with hot asphalt. If small rust spots appear, the bin should be painted with red lead or other rust-inhibiting paint.

Experience with steel bins in the Ever-Normal Granary program has indicated that bolt spacing and sheet steel gages should be as shown in table 4 for the various sizes of round metal bins.

TABLE 4.—*Gages of sheet metal and spacing of ¼-inch bolts recommended for round steel bins*

Capacity (bushels)	Bin diameter	Bin height	Sheet metal gages			Bolt spacing	Rows of bolts
			Floor	Roof	Wall		
	Feet	*Feet*	*Gage No.*	*Gage No.*	*Gage No.*	*Inches*	*Number*
500	10	8	24	26	24	2.67	1.
1,000	14	8	24	24	22	2.67	1.
1,350	14	10	24	24	22	2.67	1.
2,200	18	11	24	22	20	2.67	2 rows in bottom sheet, 1 in all others.
2,740	18	13½	24	22	18	2.67	2 rows in bottom 2 sheets, 1 row in all others.

Masonry walls should be thoroughly pointed-up on the outside and waterproofed to prevent leakage in driving rains. Unless the wall

is known to be dry, it should be furred with 2- by 2-inch wood strips and lined with matched lumber or plywood with an opening at the bottom of the lining for cleaning (fig. 21).

Roofs.—The roof must be watertight and substantial. Any standard roofing material is acceptable if in good condition, but roofs covered with tarred felt or similar lightweight materials are not suitable. Steel roofs should be carefully examined for leaks and all nails or bolts replaced, and small holes in the metal soldered.

In table 5 are shown the minimum slopes of roof allowable for the various roof coverings—asbestos, asphalt, slate and wood shingles, galvanized steel, etc. The roof of a round steel bin should have a slope of about 25° to provide the strength necessary for supporting its weight. Roofs of old round metal bins may be straightened and then the ribs reinforced with ¾-inch pipe or a 1- by 3-inch strip on edge.

TABLE 5.—*Recommended minimum roof slope per foot, with ordinary laps, for various roof coverings*

Type of roofing	Minimum allowable slope per foot, with ordinary lap	Type of roofing	Minimum allowable slope per foot, with ordinary lap
	Inches		*Inches*
Asbestos shingles:		Roll roofing, 2- to 4-inch lap	3
American pattern	6	Roll roofing, 17- to 19-inch lap	½
Dutch pattern	8	Slate	6
Hexagonal pattern	8	Tin:	
Asphalt shingles	6	Standing seam	3
Built-up roofing	½	Flat seam	½
Canvas 8 to 12 ounce	½	Wood shingles	6
Galvanized steel:			
Corrugated	3		
V-crimp	2½		

Doors and windows.—All doors and windows must be weatherproof and safe against leakage of grain. Grain doors, together with bin boards, must be tight enough to hold gases while fumigating. For this reason they should be covered on the inside, before grain is placed in the bin, with tough paper overlapping the entire opening and the jambs.

HOW TO ORDER PLANS

Working drawings and bills of materials for granary designs which are shown in this bulletin may be requested from your county agent or from the extension service of your State agricultural college. Refer to the number of the design as given in this bulletin.

Design No. 5534 (capacity: 3,200 bushels of ear corn and 2,000 bushels of small grain) and Design No. 5535 (capacity: 900 bushels of ear corn and 2,000 bushels of small grain) are not illustrated in this bulletin, but are also available. Additional designs adapted to particular States may be obtained from your State extension service.

5. METHODS OF CONDITIONING WHEAT[5]

Wheat should be threshed or combined only when it is dry enough to store safely. In some counties where moisture-testing equipment is available, the wheat moisture content can be measured by taking a small sample of the grain to the county office of the Agricultural Adjustment Administration. Removing excess moisture after storage is difficult and expensive under normal farm conditions. If, however, damp wheat is threshed because of adverse weather, the following methods of conditioning may be useful:

a. **Cleaning.**—The removal of weed seeds, chaff, and other foreign material by cleaning improves the keeping qualities of the wheat. Clean wheat has less resistance to the circulation of air, allowing heat to pass off from it more easily. Clean wheat also can be fumigated with less expense and more effectively than dirty wheat (p. 45). If the wheat contains a large amount of green weed seeds and stems, it should be cleaned immediately after threshing to prevent absorption of moisture by the wheat. To be effective the cleaning must be done within 1 or 2 hours after threshing; it is therefore desirable to have cleaning equipment mounted directly on the combine or thresher.

b. **Moving and turning.**—Wheat may be elevated or shoveled from bin to bin or from pile to pile, or spread out on the ground or in a driveway in a thin layer to avoid heating. Moving wheat by hand is laborious, but it cools the grain and thus tends to keep it from heating. Running wheat that has started to heat through a fanning mill or the cleaning mechanism of a combine or thresher will aid in cooling it and will also tend to remove some moisture if the air is dry enough.

A portable grain elevator may be used to save labor in the moving operation. For this purpose an opening, fitted with a suitable sliding door, is made in the floor of the bin. If the foundation is not high enough for this, the opening may be made in the outside wall near the floor line. The wheat is then allowed to run directly into the elevator hopper, elevated to a wagon, truck, or adjacent granary, and, by changing the position of the elevator, moved back into the bin. If several steel bins are used for storage, they may be arranged in a circle and a portable elevator used to transfer wheat from one bin to another without the use of a wagon or truck. By these methods only part of the wheat must be shoveled.

The success of these practices in cooling and drying the grain depends largely upon the temperature and humidity of the air. They should be undertaken before the wheat has heated materially, as after development of a sour or musty odor the value of the wheat is lowered and it is not eligible for loans under seal.

c. **Mixing.**—In commercial elevators small quantities of damp wheat are sometimes dried by mixing them with dry wheat. This is practicable on the farm only when elevating equipment is available to permit thorough mixing and when the moisture content of the mixed grain will be sufficiently low for safe storage. For example, 50 bushels of damp wheat, having a moisture content of 16 percent must be mixed with at least 150 bushels of dry wheat at 12-percent

[5] *See also* pages 43–47 under Other Methods for Protecting Farm-Stored Grain.

moisture content for the mixed wheat to have a moisture content of about 13 percent. The wheat must be thoroughly mixed; if the wet and dry wheat is merely placed in the bin in alternate layers, trouble almost certainly will occur.

d. **Ventilating.**—Since wheat that is properly dry and cool when stored has little need of ventilation, devices to pass air through it are not required in bins for loans under seal, and the presence of such devices in a bin will not alter the requirements as to permissible moisture content. The fumigation of a bin for insect control is also usually more difficult in a bin with the ordinary types of ventilating systems.

Experience and careful tests have shown that drying wheat by bin ventilation is usually very slow in the humid regions of the South, Southeast, and East. Chiefly because of the high relative humidity of the air, very little moisture can be removed from the grain in these areas by passing air through it. Bin ventilation does allow the escape of heat from the grain, thus retarding spoilage, but in humid regions it cannot be depended upon to remove sufficient excess moisture to prevent eventual molding and souring of wheat stored for long periods. These statements do not, of course, apply to mechanical drying by using artificial heat.

In the drier areas, good results have been obtained with the following types of ventilation with wheat which contained only a moderate amount of excess moisture:

1. Bins with floors of perforated metal fly screen laid over hardware cloth. Passage of air through bins of this type tends to equalize moisture between damp and dry layers of grain and to lower the temperature, thus retarding formation of hot pockets; but it cannot be depended upon to remove much excess moisture. This type of ventilated bin is slightly more efficient if a suction cowl is placed on top of the bin and all openings in the roof and at the eaves closed, so that air will be drawn up through the wheat. One way to close such a bin for fumigation is by banking earth around the bottom.

2. The forced ventilation system shown in figure 22 has been found very efficient where the relative humidity of the air is low. In western Kansas the moisture content of a 500-bushel bin of wheat was lowered almost 5 percent in a week by using a blower operated continuously by a ½-horsepower motor. Results such as these cannot be expected in the Southeastern and Eastern States. Almost any type of blower such as silo fillers, pneumatic grain elevators, or commercial centrifugal fans can be used to create ventilation through wheat in a bin.

After drying in such a ventilated bin, the wheat can be removed to an unventilated tight bin for storage and the ventilated bin used for drying other damp grain.

The ventilation system shown in figure 22 is also effective if the power blower is replaced with a pressure cowl set above the bin and provided with a vane so that the cowl is at all times kept facing the wind. However, for rapid drying the use of the power blower is necessary. Where the pressure cowl is used it must be removed during the winter, or securely closed, so that snow cannot be blown into the central drum or air box.

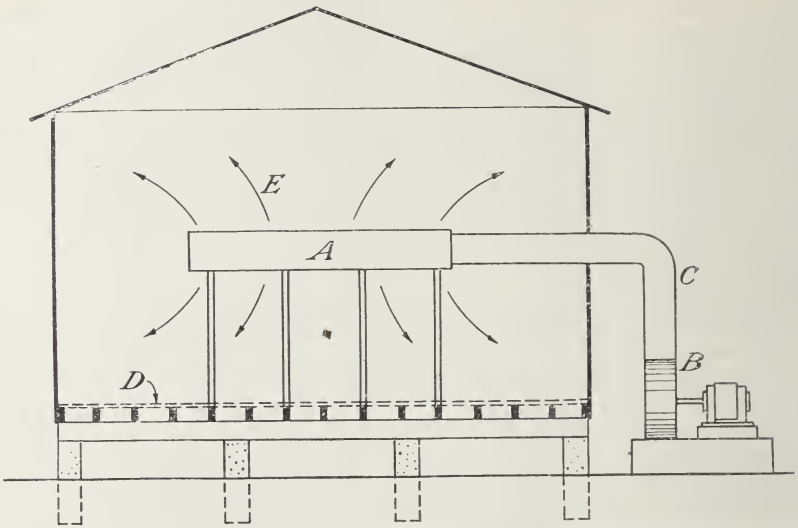

FIGURE 22.—An effective system of forced ventilation in dry climates for a 1,000-bushel bin: *A*, 8-sided air box 1 foot deep, 7 feet across, made by covering wood frame with fly screen; *B*, rotary blower driven by ½- to 1-horsepower motor; *C*, 10- to 12-inch air pipe; *D*, floor of fly screen supported by hardware cloth and wood strips; *E*, paths of air through wheat.

6. CONTROL OF INSECT PESTS IN FARM-STORED WHEAT

Stored grain is subject to the attack of a number of insects that have adapted themselves to breeding in stored grain. In many cases infestations by these insects originate on the farms where the grain is produced and where it remains in storage until it is marketed or utilized for feeding purposes. To avoid serious losses from insect damage while grain is stored on the farms, it is essential to employ methods of handling and storage that will prevent infestation, or treatment that will eradicate infestations before they reach serious proportions.

THE MORE IMPORTANT INSECTS THAT ATTACK STORED WHEAT

Of the many insects found associated with stored wheat only a few are capable of causing serious damage. A brief account of the more important of these insects is given below.

Angoumois grain moth.—The Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) is the moth most commonly found in infested grain. In the soft red winter wheat region of the Eastern and Central States it attacks wheat in the field, laying its eggs on the wheat heads. Although the initial infestation of wheat in the field is low, the moth is capable of increasing in numbers with great rapidity. In the Eastern States where threshing is often delayed, the infestation may develop to tremendous proportions before the grain can be safely stored. In some years infestation of wheat in Maryland has been observed to reach as high as 90 percent by the end of September where threshing was delayed as long as that.

When the wheat is in the straw, it is easy for the moths to make their way from one wheat head to another, with the result that in-

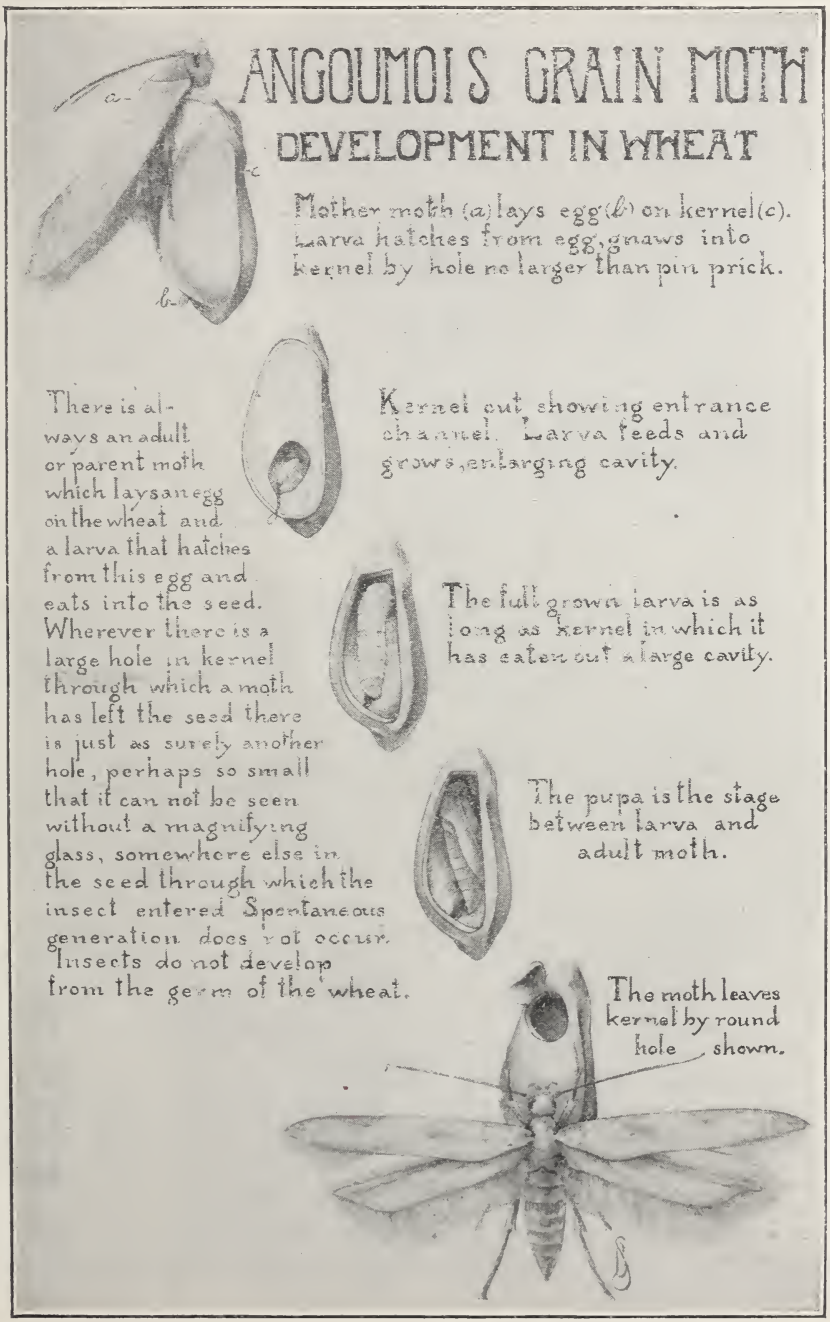

FIGURE 23.—Life cycle of Angoumois grain moth on wheat.

festation is unimpeded; but after the grain is threshed and stored it is impossible for the soft-bodied moths to make their way below the surface of the grain, and infestation is restricted to the surface grain.

Between crops the moths breed in grain in barns, granaries, and corncribs, and in waste grain in and around strawstacks.

Each female moth lays, on an average, about 40 eggs, although as many as 389 eggs have been recorded from 1 moth. The eggs, which are laid on or near the grain, hatch into minute white larvae, or caterpillars, that bore into the kernels of grain and begin feeding on the contents. When full-grown, each larva eats out a channel to the outside of the seed but leaves a thin layer of the seed coat intact. It then changes to a reddish-brown pupa, and later the adult, or moth, emerges, pushing aside the thin section of seed coat that covers the exit from the channel. The development from egg to adult may be completed in 5 weeks. Figure 23 shows the successive stages in the development of this insect in a kernel of wheat from the time the egg is laid until the moth appears.

Damage to wheat by the Angoumois grain moth can be largely eliminated by the prompt threshing of the crop. Fumigation of wheat after it is binned will prevent further damage from any infestation that is already present in it, but the grain should be inspected periodically for reinfestation, particularly in warm climates or during the warmer part of the year, and the fumigation repeated if necessary.

Other grain-infesting moths.—The Indian-meal moth (*Plodia interpunctella* (Hbn.)), the Mediterranean flour moth (*Ephestia kuehniella* Zell.), the meal moth (*Pyralis farinalis* L.), and a number of closely allied moths are general feeders on stored grain and grain products, but are seldom destructive in farm-stored wheat. The infestations are usually confined to the surface of bins, the grain sometimes being matted and webbed with the silken threads spun by the larvae, or caterpillars. They are seldom troublesome to grain that is in good condition but are attracted to high-moisture grain or grain that is going out of condition. The storage of corn in the vicinity of bins of wheat is often the cause of moth infestations spreading to binned wheat.

Rice weevil.—The rice, or black, weevil (*Sitophilus oryza* (L.)) is the most destructive insect pest of stored grain. It is a small reddish-brown beetle with head prolonged into a long, slender snout, at the end of which are a pair of stout mandibles, or jaws. It is further characterized by being marked on the back with four light-reddish or yellowish spots.

The adults fly from granaries or other places containing grain to the fields of wheat in the South and start the infestations that prove so disastrous after the grain has been harvested. In the more northern grain-growing regions, this weevil is prevalent in accumulations of old grain in and around granaries and barns and starts infestations in the new grain when it is stored in farm bins. It is not very resistant to cold, and in the North Central States infestations in farm-stored grain are usually killed out each winter except in protected situations.

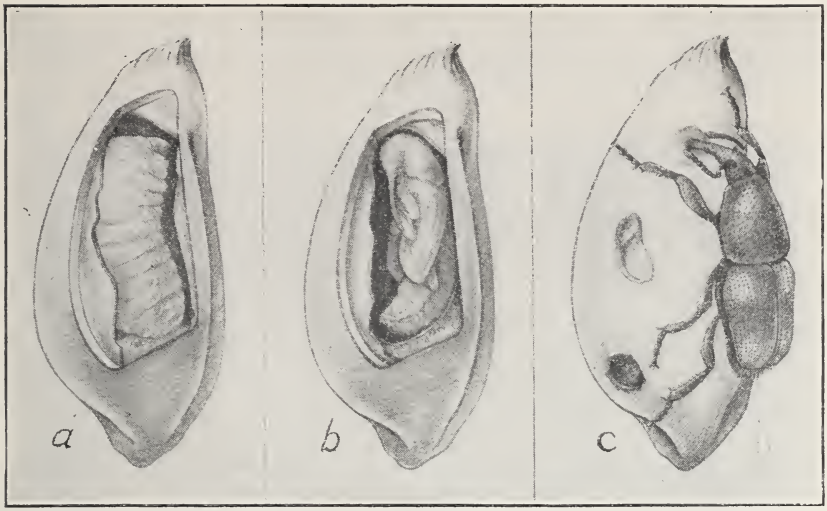

FIGURE 24.—Life stages of the rice, or black, weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on leaving the seed and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence.

The adult weevil, the full-grown larva, or grub, and the pupa are shown in figure 24. Both adults and larvae feed voraciously on a great variety of grains.

The adult weevil lives on an average of from 4 to 5 months, each female laying between 300 and 400 eggs during this period. Before laying her eggs the female bores a small hole in the grain with her mandibles. When this has been done, she turns about and lays in it an egg, which she covers with a gelatinous fluid that seals the hole. The small, white, fleshy, and legless grubs that hatch from the eggs burrow about inside the kernels and never leave them. When fully grown, these grubs transform to pupae and then to adult weevils, which bore their way out of the grain. During warm summer weather the egg, larval, and pupal stages may be passed in as few as 26 days.

A closely allied species, the granary weevil (*Sitophilus granarius* (L.)) (fig. 25), has no wings and cannot infest grain in the field. It

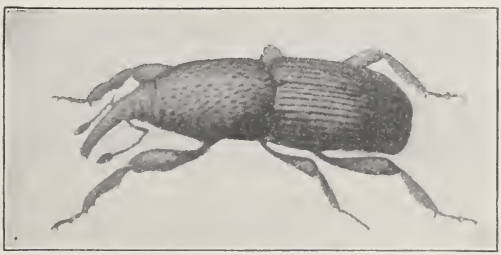

FIGURE 25.—Adult of the granary weevil.

is established on many farms in the North Central States, breeding from year to year in supplies of grain around the farm buildings. It is more resistant to cold than the rice weevil and is more likely to survive the winter in farm-stored grain.

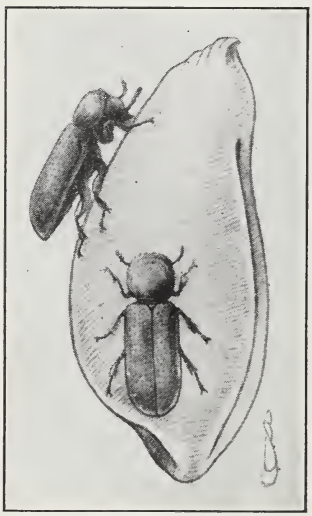

FIGURE 26.—Adults of the lesser grain borer on grain of wheat.

The lesser grain borer.—The lesser grain borer (*Rhizopertha dominica* (F.)) (fig. 26), which causes so much trouble to grain stored in terminal elevators, is beginning to be found in farm-stored grain in States as far north as Oklahoma and Kansas. It is not yet a serious pest of farm-stored grain in the main grain-growing regions.

The cadelle.—The larvae of the cadelle (*Tenebroides mauritanicus* (L.)) have the unfortunate habit of burrowing in enormous numbers into the woodwork of bins and may remain there for long periods, only to come out when fresh grain is placed in the bin. Many seemingly clean and empty bins may actually harbor thousands of hungry insects, and it is not an uncommon sight to see newly threshed grain literally swarming with worms a few weeks after it has been placed in wooden bins. Owing to this habit of the larvae, this insect is one of the commonest pests of grain stored on the farm in all parts of the country. The burrows, which are well illustrated in figure 27, also afford hiding places for many other grain-infesting insects.

The adult cadelle (fig. 28) is an elongated, oblong, and flattened black beetle about one-third of an inch long. It is one of the longest-lived of the insects that attack stored grain. Many of the adults live for more than a year and some for nearly 2 years. The females lay about 1,000 eggs each, which hatch in from 7 to 10 days into fleshy, chalky-white larvae with black heads and 2 horny black points at the end of their bodies. When fully grown the larva is about three-fourths of an inch long. The developmental period from egg to adult may be completed in 70 days under favorable conditions but frequently takes much longer.

The best insurance against this insect is to clean empty bins thoroughly and fumigate newly stored grain within a few days after it has been stored. The cadelle is highly resistant to low temperatures and also difficult to kill with fumigants.

"Bran bugs" and "fungus beetles."—A number of species of beetles that are not primary grain pests but that feed on broken grain, moldy grain, grain dust, or grain damaged by the true grain beetles are often of considerable importance not alone for the damage caused by their feeding but also because the activities of large numbers of these insects may cause heating, an increase in the moisture content of the grain, and consequent spoilage of portions of it. These insects are known to the grain trade as "bran bugs."

The different species of "bran bugs" vary in length from one-sixteenth to one-seventh inch and are usually either brown or black. The confused flour beetle (*Tribolium confusum*, Jacq.-Duv.) (fig. 29) and the red flour beetle (*T. castaneum* (Hbst.)), which are included

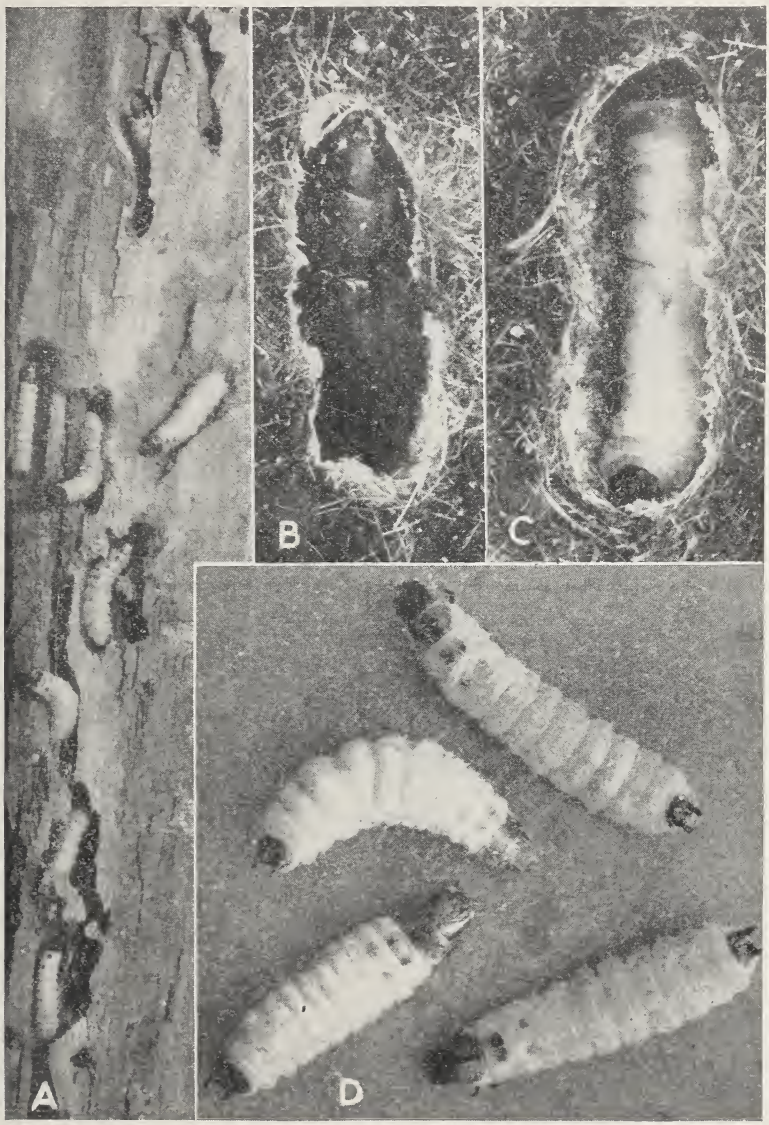

FIGURE 27.—Hibernation of the cadelle: *A*, Sectioned softwood board from granary used for wheat storage, showing numerous larvae of the cadelle using the board for a place in which to rest and pupate; *D*, cadelle larvae about to pupate; *C*, cadelle larvae hibernating in pupal chamber; *B*, same as *C*, only several months later, after larva has transformed to adult.

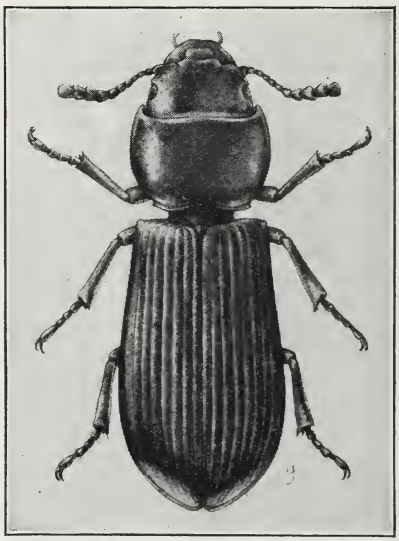

FIGURE 28.—The cadelle, one of the most common pests in farm-stored wheat.

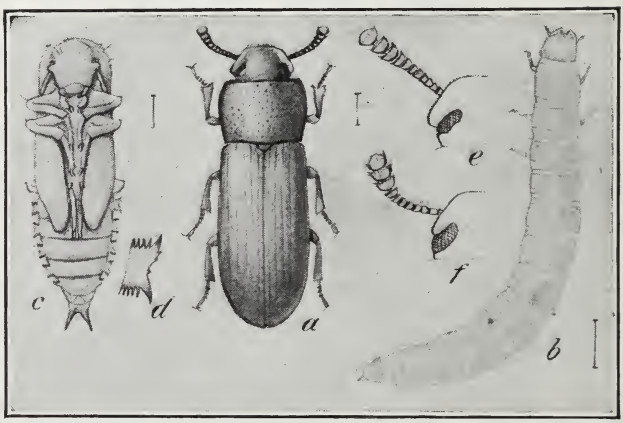

FIGURE 29.—The confused flour beetle, one of the most important of the so-called bran bugs. It is about one-sixtn of an inch long. *a*, Beetle; *b*, larva; *c*, pupa; *d*, lateral lobe of abdomen of pupa; *e*, head of beetle, showing antenna; *f*, same of the red flour beetle.

in this group, are the worst pests in flour, and their presence in wheat constitutes the chief source of infestation in flour mills. The saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) (fig. 30) and the flat grain beetle (*Laemophloeus minutus* Oliv.) (fig. 31) are other typical examples of bran bugs. These last two species are often extremely abundant in bins of wheat.

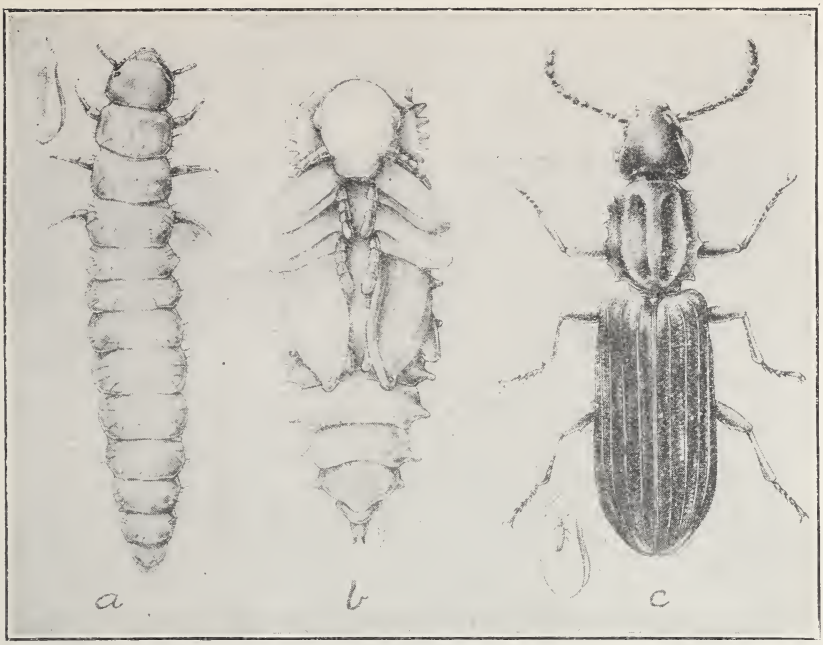

FIGURE 30.—The saw-toothed grain beetle, a frequent inhabitant of stored grain: *a*, Well-grown larvae; *b*, pupa; *c*, adult beetle.

The practice of storing mill feeds, chicken feed, and screenings in or near the granary and failing to clean out accumulations of infested grain from bins is largely responsible for the infestation of grain by bran bugs. Feeds and screenings are usually infested with insects of this type, and the habit of these insects of migrating when they become abundant, or when they are disturbed, insures the infestation of any nearby grain or cereal product.

Storing wheat in bins well removed from all milled feeds, chicken feed, or other cereal products, and cleaning out bins before the storage of wheat will do much to prevent infestation by bran bugs.

For a more detailed description of the life histories and habits of the insect pests of stored grain, the reader is referred to United States Department of Agriculture Farmers' Bulletin 1260.

FIGURE 31.—The flat grain beetle, the smallest bran bug found in stored grain, and often more numerous than any other species.

INFESTATION IN THE FIELD

In many grain-growing regions infestation starts in the field before the crops are harvested. This is particularly true in the South, where many insects survive the mild winters and where the growing grain is attacked as soon as it begins to ripen. Many of the insects involved are strong fliers and may travel for miles from sources of infestation around farm buildings.

Farther north, few species are able to survive the winter in the field; however, a certain number winter over in barns and granaries where they are protected from the cold. The congregation of large numbers of insects in stored grain or milled cereal products causes "heating" to occur. As a result, insects in these "hot spots" are not only protected from the cold but are able to continue breeding actively throughout the winter. Some of these overwintering insects later fly to the nearby fields and lay their eggs in or on the ripening grain. For the most part the resulting infestation is not serious unless conditions favorable to the insect allow a rapid increase in numbers after the grain has been placed in storage.

In the soft red winter wheat region of Pennsylvania, New Jersey, Delaware, Maryland, Virginia, and North Carolina field infestation of wheat by the Angoumois grain moth occurs each year. Outbreaks of this insect appear to occur when weather conditions are particularly favorable. A warm winter favors the survival of large numbers of the hibernating insects. If this is followed by hot weather from June to October, the field infestation is likely to build up into outbreak proportions unless grain is promptly threshed after harvest. Severe winters greatly reduce the numbers of hibernating insects, and the occurrence of an outbreak of the Angoumois grain moth after a hard winter is extremely unlikely.

OTHER SOURCES OF INFESTATION

In addition to field infestation, which may or may not be of importance, depending upon the region or the season, there are several other sources of infestation of stored grain that are of considerable concern in all grain-growing areas.

In all regions it is customary to store grain year after year in the same bins. Cracks and crevices in the bins become filled with dust and broken grain and afford hiding places for many insects. Insects such as the cadelle burrow into the sides or floors of wooden bins to rest and pupate, and later emerge in great numbers. Many bins are constructed with linings that do not fit tightly and do not extend to the top of the bin. Any space back of them forms a pocket that invariably becomes filled with grain that is difficult to remove and serves as a perpetual breeding place for insects. In the rush of harvest the cleaning out of bins is frequently slighted or omitted altogether; hence insects in accumulations of old grain and in cracks, crevices, and burrows quickly contaminate the entire new crop.

The storage of bran, shorts, and other milled feeds in or near the granary is another serious source of infestation for stored grains. These milled products frequently harbor many species of flour beetles, grain beetles, or "bran bugs," which sooner or later migrate to the bins of grain. Barns contain many products in which insects breed,

and the practice of locating granaries in corners of these buildings frequently results in the infestation of grain stored there. Illustrations of such conditions are shown in figures 32 and 33.

FIGURE 32.—A typical barn granary. Note bags of feed.

FIGURE 33.—Barn storage of wheat under adverse conditions.

REGIONAL DISTRIBUTION OF INSECT PESTS

Many of the insect pests of stored grain and milled cereals are of tropical or subtropical origin. They thrive in warm, humid climates, but do not do well in either dry or cold environments. These factors, therefore, largely determine their relative abundance and destructiveness in the various grain-growing regions of the United States.

In the extreme South, especially where rainfall is abundant and the climate is warm and humid, the storage of grain and cereal products is extremely hazardous. Insects breed with little interruption the year round, and extreme care is required to prevent heavy losses from their feeding activities.

In the soft red winter wheat area of the Eastern and Central States the insect pests of stored grain are invariably troublesome, although less difficulty is experienced in preventing loss from their attack than in the South. The colder winters have a limiting effect on their abundance that is not encountered in the South. Somewhat similar conditions of insect abundance are found in the white wheat area of California.

Grain in the Central Great Plains area is normally harvested with a low moisture content and in average years is not seriously injured by storage pests. In certain seasons, however, when rainfall is abundant at harvesttime, grain grown in this region is likely to be high in moisture content, and extensive damage to farm-stored grain from insect attack may occur.

In the spring wheat area of the Northern States and in the northern portion of the hard and soft winter wheat areas, severe winters limit the abundance of insects in stored grain, and wheat rarely suffers weevil damage. The freedom of farm-stored wheat from insect damage in this region is indicated by United States grain-inspection records. These records show that in average years less than 1 percent of the cars of grain arriving on the Minneapolis market grade weevily, even in the worst years, and it is quite likely that much of the infested grain arriving on this market may have come from other regions. Grain in the semiarid white wheat area of the Pacific Northwest is similarly remarkably free from insect infestations, owing to the cold winters and to the very low moisture content of the grain grown there.

PROTECTION OF STORED GRAIN FROM INSECTS, BY REGIONS

Since climatic conditions influencing the abundance of the insect pests of stored grain vary in different portions of the country, the difficulty of protecting farm-stored grain from insect damage also varies. For purposes of convenience the country has been divided into four general regions, as shown in figure 34, in which the problems of protecting stored grain from insect attack are distinctly

different. A brief discussion of the insect problems in each region follows:

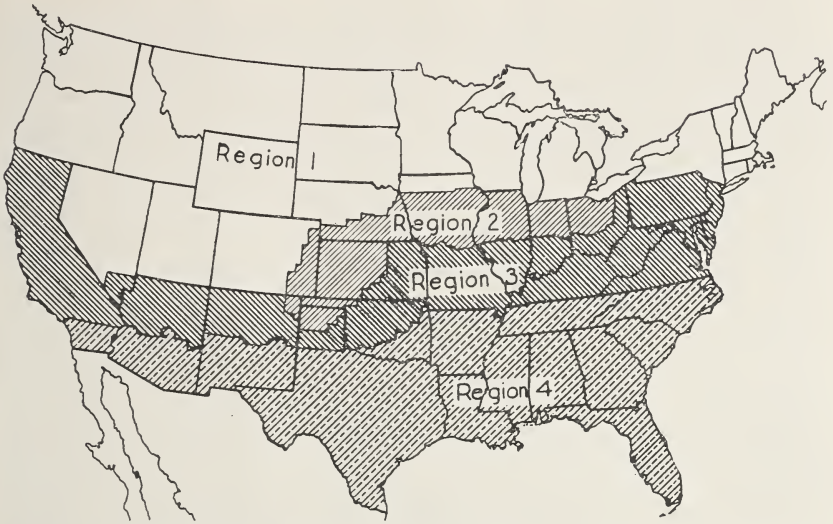

FIGURE 34.—Regional map of the United States, indicating relative hazards to farm-stored grain from insect attack. Region 1, Little if any insect damage occurs to wheat stored on the farm during the first season; Region 2, insects are troublesome during the first season in some years—frequent inspection and occasional fumigation are necessary; Region 3, insects are troublesome every year—frequent inspection and fumigation are necessary; Region 4, insect control difficult—special precautions are required if grain is to be stored safely.

Region 1 (fig. 34) comprises for the most part the spring wheat area of the Northern States, the semiarid white wheat area of the Pacific Northwest, and the northern portion of the hard and soft winter wheat areas. In these areas wheat can be stored on the farm with greater freedom from insect damage than in any other section of the country. The chief source of infestation is from insects in accumulations of old grain, in cracks, crevices, and burrows in the woodwork of bins, and from infested millfeed and chicken feed stored on the farm.

Grain-storage structures of all kinds should be thoroughly cleaned, accumulations of old grain removed, and the woodwork sprayed with a good contact spray, as described on page 44, before new grain is stored. Inspection in the fall and subsequent inspections at monthly intervals during the warm weather of the following year are recommended for detecting the presence of insect infestations. Grain found infested should be fumigated without delay.

Region 2 (fig. 34) includes the southern portion of the hard winter wheat area of the Great Plains and the northern section of the soft winter wheat area of the Central States. As in the case in region 1, the chief source of infestation is insects in accumulations of old grain in cracks, crevices, and burrows in the woodwork of bins, and infested mill feeds and chicken feed stored on the farm. During seasons of

abundant rainfall wheat is high in moisture and particularly susceptible to attack, and damage to farm-stored grain in this region may be extensive.

Grain storage structures of all kinds should be thoroughly cleaned, accumulations of old grain removed, and woodwork sprayed before new grain is stored. Monthly inspections of stored grain should be made after harvest until cold weather. Subsequent inspections at monthly intervals during the warm weather of the following year should also be made to determine the presence of insect infestations. Grain found to be seriously infested should be fumigated without delay.

Region 3 (fig. 34) comprises the central section of the soft red winter wheat area of the Eastern States, the southern portion of the Central States, and the white wheat area of California. The susceptibility of wheat to field infestations of the Angoumois grain moth in the Eastern States makes it necessary to thresh the grain as soon after harvest as the wheat is dry, to insure it against possible severe damage. In the entire region wheat is also highly susceptible to the attack of other insect pests of stored grain; hence it is necessary to fumigate all wheat as soon as the presence of serious infestations are observed.

In this region cleaning out the bins before the storage of new grain is essential. The use of a good contact spray that will penetrate cracks and burrows but will not contaminate or impart an odor to the new crop of grain is also recommended. Except during the winter, inspection of stored grain should be made monthly throughout the year.

Region 4 (fig. 34) includes areas in the South and Southeast in which farm storage is difficult and special precautions are required to protect stored grain. In this region infestation begins in the field and is frequently extensive before grain can be harvested and placed in storage. The warm, humid climate favors rapid multiplication of stored-grain insects, and the chances of sound grain becoming reinfested from outside sources are greater here than elsewhere.

Thoroughly cleaning the bins prior to storage of new grain is highly important, since accumulations of old grain in this region are invariably infested. If grain is stored, it should be fumigated immediately and monthly inspections made thereafter to determine the presence of infestations. Additional fumigations should be given whenever such infestations are discovered.

PREVENTIVE MEASURES SHOULD START ON THE FARM

In the foregoing pages it has been pointed out that in many cases infestation in stored grain originates on the farm, either as a result of field infestation or of poor storage conditions or both. The farm is therefore the logical place at which to start preventive measures.

In sections of the country where the Angoumois grain moth is destructive, and in the South where field infestation by other insects is habitual, early harvest and early threshing are essential. The Angoumois grain moth is unable to penetrate any distance below the surface of binned wheat, hence early harvest and threshing will effectively prevent serious wheat damage by this insect.

7. FUMIGATION OF FARM-STORED GRAIN

Farm-stored grain that has become seriously infested should be fumigated as soon as practicable. Since under ordinary conditions grain stored on the farm cannot be readily moved from one bin to another, the fumigants that can be used successfully are limited to those which can be applied to the surface of the grain, the so-called heavier-than-air fumigants. The chemicals in common use for this purpose are the ethylene dichloride-carbon tetrachloride mixture, carbon disulfide, and mixtures of carbon disulfide with carbon tetrachloride and other flame-depressing agents. These fumigants may be sold as such or under many different trade names.

The fumigation of farm-stored grain can ordinarily be accomplished in a satisfactory manner with simple equipment. There are, however, a number of factors affecting the efficiency of any fumigation that must be taken into consideration if successful results are to be obtained.

In order to obtain the best results in the fumigation of farm-stored grain it is necessary to have a tightly constructed bin. The average farm bin is not gas-tight, but is designed chiefly to confine the grain and protect it from the weather. Usually a maximum dosage must be used in order to compensate for the natural leakage of the gas. If bins are entirely gas-tight, minimum dosages can be used successfully.

The surface area of a bin in relation to the depth of the grain must be considered in planning the dosage. If the surface area of the grain is relatively small, a uniform coverage of the surface can be obtained with a relatively small quantity of fumigant. Furthermore, the loss of fumigant from surface evaporation is in direct proportion to surface area. If the surface area is large, and the bin is shallow, heavier dosages of fumigant are required than if the bin is deep and has a small surface area.

Bins that are too full are difficult to fumigate, since vapors of liquid fumigants applied to the surface have a tendency to roll over the edges of the bin and be lost. The surface of the grain should be level and at least 6 inches below the top of the side walls of the bin. The vapors of the fumigant will then diffuse downward through the grain instead of escaping over the top of the bin.

Caking of the surface grain, due to the webbing of insects or the condensation of moisture, may prevent the uniform penetration of the grain by the vapors of the fumigant. If there is any indication of caking, the surface should be broken up by raking to a depth of several inches.

It has been found that the uniform application of a liquid fumigant to the entire surface of a bin of grain will give the most efficient results. The vapors of such fumigants appear to channel down through a mass of grain in a vertical direction from the immediate point of application with relatively little lateral diffusion, so uniform application is essential.

Temperature and air movement are also factors of great importance. Insects are more active and more susceptible to the effect of fumigants when the weather is warm than when it is cold, and to a certain extent fumigants diffuse better and are more effective under

such conditions. At the same time it must be realized that fumigants vaporize more rapidly at higher temperatures and that the loss from surface evaporation when they are applied during periods of high temperature may more than offset the greater effectiveness at such temperatures. It has been found that at grain temperatures of from 65° to 75° F. excellent results can be obtained, with a minimum loss of fumigant through evaporation. During periods of warm weather when fumigation is required, it is advisable to treat bins during the early morning while the air above the grain is comparatively cool. High winds greatly increase the loss of fumigants resulting from surface evaporation and further decrease the efficiency of a fumigation by causing a drift of the fumigant to one side of a bin. Whenever possible bins should be fumigated when there is little air movement.

The presence of a serious infestation of insects in a bin of wheat can usually be determined by merely running the hand and arm down into the wheat. If the wheat is warm it is usually a reliable indication of the presence and activity of many insects and that the bin requires prompt fumigation. Isolated colonies of insects in deep bins can often be located by the use of a thermometer which is thrust into various parts of the bin on the end of a stick. The thermometer should be shielded by a metal jacket in order to prevent breakage, and it should be left in one place long enough to register the correct temperature. A common practice is to leave a metal or wooden rod sticking in the grain so that it can be withdrawn at intervals and felt to see if it is warm, indicating heating of the wheat.

ETHYLENE DICHLORIDE-CARBON TETRACHLORIDE MIXTURES

A mixture of 3 parts by volume of ethylene dichloride with 1 part of carbon tetrachloride has been found to be well adapted for the treatment of farm-stored grain, and its use is recommended wherever possible.

Ethylene dichloride is a colorless liquid with an odor similar to that of chloroform. On exposure to air it evaporates slowly, forming a vapor that is slightly heavier than air. When applied to the surface of a bin of grain the vapors diffuse downward through the grain to the bottom. No adverse effect upon the germination of the grain is noticeable regardless of the concentration, the length of exposure, or the moisture content of the grain.

Since the vapors of ethylene dichloride are inflammable, it is customary to use this fumigant in combination with carbon tetrachloride. A mixture of 3 parts by volume of ethylene dichloride with 1 part of carbon tetrachloride is free from fire hazard under ordinary conditions. This mixture is sold under many trade names and can be purchased from the manufacturers at a cost of approximately 75 cents per gallon.

In applying the mixture to a bin of grain the fumigator should avoid exposing himself to heavy concentrations of the vapors. The most satisfactory method is to apply the fumigant from the outside of the bin as shown in figure 35. An inexpensive bucket sprayer or a larger power sprayer is used to distribute the liquid uniformly over the surface of the grain. Do not use spray nozzles that will make a fine mist, or loss from evaporation will be excessive. If a small bin

FIGURE 35.—Applying the ethylene dichloride-carbon tetrachloride mixture with a hand-operated sprayer. A uniform distribution of the fumigant over the surface of the grain can be obtained in this way without exposing the operator to strong concentrations of the gas.

only is to be treated and a sprayer is not available, the fumigant can be applied by means of a sprinkling can as shown in figure 36.

It is unwise to attempt to fumigate on a large scale with a sprinkling can since the vapors have an anaesthetic action when breathed in concentrated form, and fumigators exposed to the vapors

for any appreciable period are likely to be made seriously ill. A gas mask provided with a suitable canister, designed to protect against this gas, should always be worn by anyone who is exposed to the concentrated vapors for more than a very brief period.

FIGURE 36.—Applying the ethylene dichloride-carbon tetrachloride mixture to the surface of a bin of grain with a sprinkling can. A gas mask should be worn by the fumigator if more than one small bin is to be treated.

A dosage of 6 gallons of the mixture per 1,000 bushels of grain is the recommended dosage in tight, well-constructed bins. If, however, the bin is shallow and has a large surface area, it may be necessary to increase the dosage to 8 gallons per 1,000 bushels.

CARBON DISULFIDE

Carbon disulfide has long been a popular fumigant for the treatment of farm-stored grain. **It is dangerous to use, however, owing to the highly inflammable and explosive nature of its vapors when mixed with air. When other effective fumigants are available, it is recommended that they be used in preference to carbon disulfide. It should never be used in treating bins located in barns. Fire insurance is void while carbon disulfide is being used.**

Carbon disulfide is a colorless, volatile liquid that evaporates on exposure to air, forming a heavy vapor that acts in very much the same manner as the ethylene dichloride-carbon tetrachloride mix-

ture. It is applied to the surface of the grain in a bin at the rate of 3 gallons per 1,000 bushels.

It is unsafe to apply this material with a sprayer owing to the danger of an explosion from static electricity. It can be applied with a sprinkling can.

The vapors of carbon disulfide are poisonous to human beings if breathed for a long period. Exposure to light concentrations may induce a feeling of giddiness, which, however, will quickly pass off when one comes out into the fresh air. Small quantities of carbon disulfide can be handled without danger to health by the ordinary person, although persons having any heart trouble should take little part in its application. If very much of the material is to be applied, the fumigator must wear a gas mask.

Remember—lighted lanterns, pilot lights on gas stoves and heaters, sparks from electric switches, sparks formed by hammering upon metals, lighted cigars, even hot steam pipes and static and frictional electricity, may cause an explosion of carbon disulfide vapor; therefore fire in any form, or excessive heat, or frictional or static electricity should not be allowed near a bin or building that is being fumigated with this chemical.

Carbon disulfide weighs 10½ pounds per gallon and ranges in cost from about 6 cents a pound in 500-pound lots to 30 cents a pound in 1-pound lots.

MIXTURES OF CARBON DISULFIDE WITH OTHER CHEMICALS

Mixtures of carbon disulfide with other chemicals such as carbon tetrachloride and sulfur dioxide, made for the purpose of reducing the fire hazard, are now available commercially at a price of about $2 per gallon f. o. b. factory. These mixtures consist of approximately 20 percent of carbon disulfide and 80 percent of carbon tetrachloride, to which may be added a small quantity of sulfur dioxide or other chemicals. When properly made, such mixtures appear to be relatively free from fire hazard. It is not advisable for the layman to attempt the manufacture of such mixtures, since the safety of the fumigant from fire hazard is dependent upon its proper preparation. Only such mixtures as are sanctioned by fire insurance underwriters should be used. The toxicity of carbon tetrachloride to man is about equivalent to that of carbon disulfide.

It is recommended that these mixtures be applied in the same manner and at the same dosages recommended for the ethylene dichloride-carbon tetrachloride mixture.

8. OTHER MEASURES FOR PROTECTING FARM-STORED GRAIN

In many parts of the country facilities for the storage of grain are entirely inadequate. Conditions such as are illustrated in figure 33, where wheat is merely dumped on the floor in any convenient corner of the barn, are all too frequent. Grain so stored is open to the attack of insects and rodents that abound in such situations, and heavy losses are inevitable.

In years of high production when transportation facilities are insufficient to care for the surplus crop, it is sometimes stored tem-

porarily in any structure that will afford protection from the weather, but storage for an extended period should be in structures adapted for protecting the grain from insect attack. In the Great Plains region, for lack of storage space, grain is sometimes piled on the ground as shown in figure 37. Under the semiarid conditions that

FIGURE 37.—Thousands of bushels of grain piled on ground in western Kansas awaiting transfer to storage.

prevail after harvest in this region, grain can be stored for short periods in this manner without great danger. Similar conditions occur in portions of the Pacific Northwest, where bagged grain is often stored in the open alongside of railroads until such time as it can be hauled away.

In general, however, small grains should be stored in bins tight enough for effective fumigation and located far enough away from barns or other buildings to prevent infestation from such sources and to avoid exposure of other farm buildings to danger from fire in case an inflammable fumigant is used.

The type of construction for grain storage on the farm will doubtless vary with the region and the type of farming practiced. A detailed discussion of storage structures suitable for the farm storage of grain will be found elsewhere in this bulletin.

CARE AND PREPARATION OF FARM STRUCTURES

Before newly harvested grain is placed in storage, it is extremely important to see that the bins or granaries are clean and free from accumulations of old grain or feed that may harbor insects. Small lots of grain on hand from the previous season should be fed, fumigated, or disposed of, some time before harvest. The granaries should be thoroughly swept out, any breaks repaired, and pockets or dead spaces around the bin cleaned out, filled up, or sealed.

With wooden bins the use of a contact spray will be found useful. Care should be taken to use a spray that will not leave any odor or otherwise contaminate the grain. A satisfactory spray can be made of any good, odorless, tasteless kerosene-type oil mixed with pyrethrum extract in the proportion of 1 gallon of the extract to 19 gallons of the oil. A less expensive spray recommended by Farrar *et al.*[6] consists of the following ingredients:

Dormant-tree spray oil	1 gallon
Lye	3 ounces
Water	9 gallons

A gallon of this spray will cover about 50 square feet of bin surface.

[6] Farrar, M. D., Winburn, T. F., and Flint, W. P., 1941: How to Know and Control Stored-Grain Insects. Univ. of Ill. Circ. 512, 16 pp., illus.

AVOID STORAGE OF HIGH-MOISTURE GRAIN[7]

The moisture content of stored grain is one of the most important factors affecting its susceptibility to insect attack. The insects that breed in stored grain are dependent on their food supply for the moisture required for carrying on their life processes in a normal manner. If the moisture content of the grain is high, it is favorable to a rapid increase in the numbers of insects breeding in it. If, however, the moisture content of the grain is too low, the water required for carrying on the vital life processes can be obtained only by breaking down the food reserves of the body. Loss of weight results from this consumption of the reserve body tissues and the insects eventually die. The water requirements naturally differ with each species of insect, and some are able to subsist on drier grain than others.

The common insect pests of stored grain do not appear to breed in grain that has a moisture content of 9 percent or lower, and adults of the rice weevil and the granary weevil soon die in such grain. Some of the adult bran bugs survive for considerable periods in dry wheat, but they are unable to multiply. Information on the exact moisture requirements of these insects is not complete, but it is known that they will breed rapidly in wheat with a moisture content of 12 percent or above, and the higher the moisture content of the grain the more rapid their development. Many of them appear to thrive best when the grain is so damp that it begins to mold. It is extremely important, therefore, that grain be stored in as dry a condition as possible.

IMPORTANCE OF STORING CLEAN GRAIN[7]

Grain that is to be placed in storage should be as free as possible from broken kernels and foreign material. Many bran bugs and lesser grain pests are unable to survive in whole, sound grain that is in good condition. They breed rapidly in dirty grain that is full of broken kernels, and by their activities they produce heat and moisture that cause the grain to go out of condition. Grain that has a high percentage of dockage is also more difficult to fumigate than clean grain, since accumulations of foreign material appear to prevent the free passage of fumigants through the bin.

MECHANICAL HANDLING[7]

Ordinarily it is considered impractical to handle small grain on the farm to improve its condition unless the storage is of the elevator type equipped with machinery for elevating and transferring the grain. In the Great Plains region, where the combine harvester is almost universally used, farm-stored wheat that is found to be going out of condition is sometimes run through the combine with profit. Many insects are removed and the general condition of the grain is improved in the process. Small quantities of grain can be cleaned with a fanning mill. Since immature stages of the rice and granary weevils are not free living, but are found inside the kernels, they are not removed by cleaning.

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[7] *See also* Methods of Conditioning Wheat, p. 24.

USE OF DUSTS TO PROTECT GRAIN[7]

The mixing of finely ground inert dust such as sand, clay, wood ashes, etc., with grain to protect it from insect attack has been advocated from time to time, but, aside from the impracticability of mixing large quantities of inert dusts with grain, it has been found that none of them can be depended upon to give adequate protection to grain under actual storage conditions. Development of insects in grain with which dusts are mixed is somewhat retarded, but if the moisture content of the grain is favorable for insect development serious damage will not be prevented by the use of inert dusts.

In addition to inert dusts, a number of chemical dusts have been tried at one time or another for protecting stored grain from insect attack. These include camphor, naphthalene, paradichlorobenzene, salt, lime, sulfur, magnesium oxide, borax, copper carbonate, copper sulfate, sodium fluosilicate, barium fluosilicate, and various compounds of mercury or arsenic. There is little doubt that many of the poisonous dusts are highly effective. They are, however, of value only in protecting grain that is intended for seeding purposes, and it is doubtful whether they should even be recommended for this purpose, owing to the chance that treated seed may accidentally be used for food by man or animals. Naphthalene and paradichlorobenzene act as fumigants and are commonly used to protect seed samples or seed to be used for planting purposes. Seed so treated, if later fed to animals, has been found to taint the meat and in the case of poultry to impart an obnoxious flavor to the eggs as well.

RIDDING PREMISES OF RATS

Several of the references in the preceding pages call attention to construction features that will exclude rats. Where it is not prac-

FIGURE 38.—Killing rats with exhaust gas from an automobile. Rats might be excluded by raising the building to 2 feet above the ground and capping the piers with large metal pans.

[7] *See also* Methods of Conditioning Wheat, p. 24.

tical to apply these methods to old buildings, other measures for dealing with rats and mice are needed.

Small buildings may be kept free from rats and mice by the periodical use of carbon monoxide gas from the exhaust of automobiles or tractors (fig. 38). All small openings should first be closed with burlap or other packing and the exhaust piped into the building with a short length of hose pipe. The engine should be allowed to run at moderate speed for 10 minutes or more for small buildings. Pulling the choke on the motor in order to give a richer mixture will produce a higher percentage of carbon monoxide in the exhaust.

This method of fumigation has been found practical and reliable; it is also inexpensive and free from fire hazard. Other ways of controlling rats are described in Conservation Bulletin 8, Rat Control, issued by the Fish and Wildlife Service, United States Department of the Interior.

APPENDIX

OFFICIAL GRAIN STANDARDS OF THE UNITED STATES FOR WHEAT[1]

For the purposes of the official grain standards of the United States for wheat:[2]

Wheat.—Wheat shall be any grain which, before the removal of dockage, consists of 50 percent or more of wheat and not more than 10 percent of other grains for which standards have been established under the provisions of the United States Grain Standards Act, and which, after the removal of dockage, contains not more than 50 percent of broken kernels of grain of any size. The term wheat in these standards shall not include emmer, spelt, einkorn, Polish wheat, and poulard wheat.

Classes.—Wheat shall be divided into seven classes, as follows: Class I, Hard Red Spring Wheat; Class II, Durum Wheat; Class III, Red Durum Wheat; Class IV, Hard Red Winter Wheat; Class V, Soft Red Winter Wheat; Class VI, White Wheat; and Class VII, Mixed Wheat.

Grades.—Wheat shall be graded and designated according to the respective grade requirements of the numerical grades and Sample grade of its appropriate class or subclass, and according to the special grades when applicable.

HARD RED SPRING WHEAT (CLASS I)

This class shall include all varieties of hard red spring wheat, and may include not more than 10 percent of wheats of other classes. This class shall be divided into three subclasses, as follows:

Subclass (A) Dark Northern Spring.—This subclass shall include wheat of the class Hard Red Spring Wheat consisting of 75 percent or more of dark, hard, and vitreous kernels. This subclass shall not include more than 10 percent of wheat of the variety Humpback.

Subclass (B) Northern Spring.—This subclass shall include wheat of the class Hard Red Spring Wheat consisting of more than 25 percent but less than 75 percent of dark, hard, and vitreous kernels. This subclass shall not include more than 10 percent of wheat of the variety Humpback.

Subclass (C) Red Spring.—This subclass shall include wheat of the class Hard Red Spring Wheat consisting of not more than 25 percent of dark, hard, and vitreous kernels. This subclass shall also include wheat of the class Hard Red Spring Wheat consisting of more than 10 percent of the variety Humpback.

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[1] From Handbook of Official Grain Standards of the United States, United States Department of Agriculture, Agricultural Marketing Service, 101 pp., illus. October 1940.

[2] The specifications of these standards shall not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act.

TABLE 1.—*Class I—Hard Red Spring Wheat : Grade requirements for (a) Dark Northern Spring, (b) Northern Spring, (c) Red Spring*

Grade No.	Minimum test weight per bushel	Maximum limits of—					
		Damaged kernels (wheat and other grains)		Foreign material		Wheats of other classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Durum and/or Red Durum
	Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1 Heavy [1] [2]	60	2	0. 1	1	0. 5	5	2
1 [2]	58	2	. 1	1	. 5	5	2
2 [2]	57	4	. 2	2	1. 0	10	3
3	55	7	. 5	3	2. 0	10	5
4	53	10	1. 0	5	3. 0	10	10
5	50	15	3. 0	7	5. 0	10	10
Sample grade	Sample grade shall include wheat of the subclass Dark Northern Spring, or Northern Spring, or Red Spring, which does not come within the requirements of any of the grades from No. 1 Heavy to No. 5, inclusive; or which contains more than 16 percent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

[1] Applies to each of the subclasses Dark Northern Spring, Northern Spring, and Red Spring.
[2] The wheat in grades No. 1 Heavy and No. 1 of this class may contain not more than 7 percent, and the wheat in grade No. 2 of this class may contain not more than 10 percent, of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by $\frac{3}{8}$ inch long.

DURUM WHEAT (CLASS II)

This class shall include all varieties of common durum wheat, and may include not more than 10 percent of wheats of other classes. This class shall be divided into three subclasses, as follows:

Subclass (A) Hard Amber Durum.—This subclass shall include wheat of the class Durum Wheat consisting of 75 percent or more of hard and vitreous kernels of amber color.

Subclass (B) Amber Durum.—This subclass shall include wheat of the class Durum Wheat consisting of 60 percent or more but less than 75 percent of hard and vitreous kernels of amber color.

Subclass (C) Durum.—This subclass shall include wheat of the class Durum Wheat consisting of less than 60 percent of hard and vitreous kernels of amber color.

RED DURUM WHEAT (CLASS III)

This class shall include all varieties of Red Durum Wheat, and may include not more than 10 percent of wheats of other classes.

TABLE 2.—*Class II—Durum Wheat and Class III—Red Durum Wheat: Grade requirements for the subclasses (a) Hard Amber Durum, (b) Amber Durum, and (c) Durum, of the class Durum Wheat, and for the class Red Durum Wheat*

Grade No.	Minimum test weight per bushel	Maximum limits of—					
		Damaged kernels (wheat and other grains)		Foreign material		Wheats of other classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Soft Red Winter, White, and Red Durum, singly or combined [1]
	Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1 [2]	60	2	0. 1	1	0. 5	[3] 5	3
2 [2]	58	4	. 2	2	1. 0	10	5
3 [2]	56	7	. 5	3	2. 0	10	10
4	54	10	1. 0	5	3. 0	10	10
5	51	15	3. 0	7	5. 0	10	10
Sample grade	Sample grade shall include wheat of the subclass Hard Amber Durum, or Amber Durum, or Durum, or wheat of the class Red Durum Wheat, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains more than 16 percent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

[1] These specifications do not apply to the class Red Durum Wheat, or to the subclass Durum.

[2] The wheat in grades No. 1 and No. 2 of each of these classes may contain not more than either (*a*) 7 percent of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by ¾ inch long, or (*b*) 10 percent of all such material that will pass through said sieve together with the broken kernels of grain of any size which remain on said sieve; and the wheat in grade No. 3 of each of these classes may contain not more than either (*a*) 10 percent of shrunken and/or broken kernels of grain and other matter that will pass through said sieve, or (*b*) 15 percent of all such material that will pass through said sieve together with the broken kernels of grain of any size which remain on said sieve.

[3] No. 1 Red Durum may contain 10 percent of wheats of other classes.

HARD RED WINTER WHEAT (CLASS IV)

This class shall include all varieties of hard red winter wheat, and may include not more than 10 percent of wheats of other classes. This class shall be divided into three subclasses, as follows:

Subclass (A) Dark Hard Winter.—This subclass shall include wheat of the class Hard Red Winter Wheat consisting of 75 percent or more of dark, hard, and vitreous kernels.

Subclass (B) Hard Winter.—This subclass shall include wheat of the class Hard Red Winter Wheat consisting of more than 25 percent but less than 75 percent of dark, hard, and vitreous kernels.

Subclass (C) Yellow Hard Winter.—This subclass shall include wheat of the class Hard Red Winter Wheat consisting of not more than 25 percent of dark, hard, and vitreous kernels.

TABLE 3.—*Class IV—Hard Red Winter Wheat: Grade requirements for (a) Dark Hard Winter, (b) Hard Winter, (c) Yellow Hard Winter*

Grade No.	Minimum test weight per bushel	Maximum limits of—					
		Damaged kernels (wheat and other grains)		Foreign material		Wheats of other classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Durum and/or Red Durum
	Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1 [1]	60	2	0. 1	1	0. 5	5	1
2 [1]	58	4	. 2	2	1. 0	10	2
3 [1]	56	7	. 5	3	2. 0	10	3
4	54	10	1. 0	5	3. 0	10	10
5	51	15	3. 0	7	5. 0	10	10
Sample grade	Sample grade shall include wheat of the subclass Dark Hard Winter, or Hard Winter, or Yellow Hard Winter, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains more than 15.5 percent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

[1] The wheat in grades No. 1 and No. 2 of this class may contain not more than 7 percent, and the wheat in grade No. 3 of this class may contain not more than 10 percent, of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by $\frac{3}{8}$ inch long.

SOFT RED WINTER WHEAT (CLASS V)

This class shall include all varieties of soft red winter wheat and may include not more than 10 percent of wheats of other classes. This class shall be divided into two subclasses, as follows:

Subclass (A) Red Winter.—This subclass shall include wheat of the class Soft Red Winter Wheat consisting of both light and dark colored kernels. This subclass shall not include more than 10 percent of Soft Red Winter Wheat grown west of the Great Plains area of the United States.

Subclass (B) Western Red.—This subclass shall include wheat of the class Soft Red Winter Wheat consisting of more than 10 percent of wheat of this class grown west of the Great Plains area of the United States.

TABLE 4.—*Class V—Soft Red Winter Wheat: Grade requirements for (a) Red Winter, (b) Western Red*

Grade No.	Minimum test weight per bushel	Maximum limits of—					
		Damaged kernels (wheat and other grains)		Foreign material		Wheats of other classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Durum and/or Red Durum
	Lb.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1 [1]	60	2	0. 1	1	0. 5	5	0. 5
2 [1]	58	4	. 2	2	1. 0	10	1. 0
3 [1]	56	7	. 5	3	2. 0	10	2. 0
4	54	10	1. 0	5	3. 0	10	10. 0
5	51	15	3. 0	7	5. 0	10	10. 0
Sample grade	Sample grade shall include wheat of the subclass Red Winter, or Western Red, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains more than 15.5 percent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

[1] The wheat in grades No. 1 and No. 2 of this class may contain not more than 7 percent and the wheat in grade No. 3 of this class may contain not more than 10 percent, of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by ⅜ inch long.

WHITE WHEAT (CLASS VI)

This class shall include all varieties of white wheat, whether winter or spring grown, and may include not more than 10 percent of wheats of other classes. This class shall be divided into four subclasses, as follows:

Subclass (A) Hard White.—This subclass shall include all wheat of the class White Wheat consisting of 75 percent or more of hard (not soft and chalky) kernels. This subclass shall not include more than 10 percent of Sonora wheat or wheat of the white club varieties, either singly or in any combination.

Subclass (B) Soft White.—This subclass shall include wheat of the class White Wheat consisting of less than 75 percent of hard (not soft and chalky) kernels. This subclass shall not include more than 10 percent of Sonora wheat or wheat of the white club varieties, either singly or in any combination.

Subclass (C) White Club.—This subclass shall include wheat of the class White Wheat consisting of Sonora wheat or wheat of the white club varieties, either singly or in any combination. This subclass shall not include more than 10 percent of common white wheat other than Sonora, either singly or in any combination.

Subclass (D) Western White.—This subclass shall include wheat of the class White Wheat which contains more than 10 percent of Sonora wheat or wheat of the white club varieties, either singly or in any combination, and which also contains more than 10 percent of common white wheat other than Sonora.

TABLE 5.—*Class VI—White Wheat: Grade requirements for (a) Hard White, (b) Soft White, (c) White Club, (d) Western White*

Grade No.	Minimum test weight per bushel	Maximum limits of—					
		Damaged kernels (Wheat and other grains)		Foreign material		Wheats of other classes	
		Total	Heat-damaged	Total	Matter except other grains	Total	Durum and/or Red Durum
	Lbs.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
1 [1]	60	2	0. 1	1	0. 5	5	0. 5
2 [1]	58	4	. 2	2	1. 0	10	1. 0
3 [1]	56	7	. 5	3	2. 0	10	2. 0
4	54	10	1. 0	5	3. 0	10	10. 0
5	51	15	3. 0	7	5. 0	10	10. 0
Sample grade	Sample grade shall include wheat of the subclass Hard White, or Soft White, or White Club, or Western White, which does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains more than 15.5 percent of moisture; or which contains inseparable stones and/or cinders; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.						

[1] The wheat in grades No. 1 and No. 2 of this class may contain not more than 7 percent, and the wheat in grade No. 3 of this class may contain not more than 10 percent, of shrunken and/or broken kernels of grain and other matter that will pass through a 20-gage metal sieve with slotted perforations 0.064 inch wide by 3/8 inch long.

MIXED WHEAT (CLASS VII)

This class shall include all mixtures of wheat not provided for in the classes from I to VI, inclusive.

GRADE REQUIREMENTS AND DESIGNATIONS

Mixed Wheat shall be graded according to the numerical and Sample grade requirements of the class of wheat which predominates in the mixture, except that the grade specifications for the factor "wheats of other classes" and the grade specifications for "No. 1 Heavy" in the standards for hard red spring wheat, shall be disregarded.

The grade designation for Mixed Wheat shall be stated as provided in paragraph (a), (b), or (c) of this section:

(a) Except as specified in paragraphs (b) and (c) of this section, the grade designation for Mixed Wheat shall include successively, in the order named, (1) the number of the grade or the words "Sample grade," as the case may be, (2) the words "Mixed Wheat," and (3) the name and approximate percentage of each class of wheat which constitutes more than 10 percent of the mixture in the order of its predominance: but if only one class exceeds 10 percent of the mixture, the name and approximate percentage of that class shall be included in the grade designation, followed by the name and approximate percentage of at least one other class.

(b) **Amber Mixed Durum.**—Amber Mixed Durum shall be Mixed Wheat consisting of a mixture of Durum and other wheats, which contains not more than a total of 15 percent of wheats other than common durum and which contains not less than 60 percent of Durum kernels that are hard and vitreous and of amber color. Amber Mixed Durum may contain not more than 5 percent of red durum, white, and soft red winter wheat, singly or combined.

The grade designation for Amber Mixed Durum shall include successively, in the order named, (1) the number of the grade or the words "Sample grade," as the case may be, and (2) the words "Amber Mixed Durum."

(c) **Mixed Durum.**—Mixed Durum shall be Mixed Wheat consisting of a mixture of Durum and other wheats, which contains not more than a total of 20 percent of wheats other than common durum. Mixed Durum may contain not more than 5 percent of Red Durum wheat, and may contain not more than 5 percent of white and soft red winter wheat, singly or combined.

The grade designation for Mixed Durum shall include successively, in the order named, (1) the number of the grade or the words "Sample grade," as the case may be, and (2) the words "Mixed Durum."

DOCKAGE

Dockage includes weed seeds, weed stems, chaff, straw, grain other than wheat, sand, dirt, and any other foreign material, which can be removed readily from the wheat by the use of appropriate sieves and cleaning devices; also undeveloped, shriveled, and small pieces of wheat kernels removed in properly separating the foreign material, and which cannot be recovered by properly rescreening or recleaning.

The quantity of dockage shall be calculated in terms of percentage based on the total weight of the grain including the dockage. The percentage of dockage so calculated, when equal to 1 percent or more, shall be stated in terms of whole percent, and when less than 1 percent shall not be stated. A fraction of a percent shall be disregarded. The word "Dockage," together with the percentage thereof, shall be added to the grade designation.

SPECIAL GRADES FOR WHEAT

TOUGH WHEAT

Definition.—Tough wheat shall be (a) wheat of any of the classes Hard Red Winter Wheat, Soft Red Winter Wheat, or White Wheat, or of the class Mixed Wheat in which wheat of any one of the classes Hard Red Winter Wheat, or Soft Red Winter Wheat, or White Wheat, predominates, which contains more than 14 percent but not more than 15.5 percent of moisture, and (b) wheat of any of the classes Hard Red Spring Wheat, or Durum Wheat, or Red Durum Wheat, or of the class Mixed Wheat in which wheat of any one of the classes Hard Red Spring Wheat, or Durum Wheat, or Red Durum Wheat, predominates, which contains more than 14.5 percent but not more than 16 percent of moisture.

Grades.—Tough wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not tough, and there shall be added to, and made a part of, the grade designation, the word "Tough."

SMUTTY WHEAT

Definition.—Smutty wheat shall be wheat which has an unmistakable odor of smut, or which contains balls, portions of balls, or spores, of smut, in excess of a quantity equal to 14 balls of average size in 250 grams of wheat.

Smutty wheat shall be graded and designated according to the method described either in paragraph (a) or paragraph (b) of this section.

(a) **Smut dockage.**—Before the determination of smut dockage as provided in this paragraph, the wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not smutty. The smut shall be removed by scouring and the loss in weight of the wheat caused by the removal of the smut shall be calculated in terms of percentage based on the total weight of the grain when free from dockage. The percentage so calculated shall be stated in terms of half percent, whole percent, or whole and half percent, as the case may be. A fraction of a half percent shall be disregarded. The percentage of the smut dockage, so calculated and stated, shall be added to the grade designation, preceding the statement of dockage, if any.

(b) **"Light Smutty" and "Smutty."**—Smutty wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not smutty; and

(1) In the case of smutty wheat which has an unmistakable odor of smut, or which contains balls, portions of balls, or spores, of smut, in excess of a quantity equal to 14 balls but not in excess of a quantity equal to 30 balls of average size in 250 grams of wheat, there shall be added to, and made a part of, the grade designation, the words "Light Smutty"; and

(2) In the case of smutty wheat which contains balls, portions of balls, or spores, of smut, in excess of a quantity equal to 30 balls of average size in 250 grams of wheat, there shall be added to, and made a part of, the grade designation, the word "Smutty."

GARLICKY WHEAT

Definition.—Garlicky wheat shall be wheat which contains two or more green garlic bulblets, or an equivalent quantity of dry or partly dry bulblets, in 1,000 grams of wheat.

Grades.—Garlicky wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not garlicky; and

(1) In the case of garlicky wheat which contains two or more but not more than six green garlic bulblets, or an equivalent quantity of dry or partly dry bulblets, in 1,000 grams of wheat, there shall be added to, and made a part of, the grade designation, the words "Light Garlicky"; and

(2) In the case of garlicky wheat which contains more than six green garlic bulblets, or an equivalent quantity of dry or partly dry bulblets, in 1,000 grams of wheat, there shall be added to, and made a part of, the grade designation, the word "Garlicky."

WEEVILY WHEAT

Definition.—Weevily wheat shall be wheat which is infested with live weevils or other insects injurious to stored grain.

Grades.—Weevily wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not weevily, and there shall be added to, and made a part of, the grade designation, the word "Weevily."

ERGOTY WHEAT

Definition.—Ergoty wheat shall be wheat which contains ergot in excess of 0.3 percent.

Grades.—Ergoty wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not ergoty, and there shall be added to, and made a part of, the grade designation the word "Ergoty."

TREATED WHEAT

Definition.—Treated wheat shall be wheat which has been scoured, limed, washed, sulphured, or treated in such a manner that its true quality is not reflected by either the numerical grade or the Sample grade designation alone.

Grades.—Treated wheat shall be graded and designated according to the grade requirements of the standards applicable to such wheat if it were not treated, and there shall be added to, and made a part of, the grade designation, a statement indicating the kind of treatment.

DEFINITIONS

Basis of grade determinations.—Each determination of dockage, temperature, odor, garlic, and live weevils, or other insects injurious to stored grain, shall be upon the basis of the grain as a whole. All other determinations shall be upon the basis of the grain when free from dockage.

Percentages.—Percentages, except in the case of moisture, shall be percentages ascertained by weight.

Percentage of moisture.—Percentage of moisture shall be that ascertained by the air oven and the method of use thereof described in Service and Regulatory Announcements No. 147 of the Bureau of Agricultural Economics of the United States Department of Agriculture, or ascertained by any device and method which give equivalent results in the determination of moisture.

Test weight per bushel.—Test weight per bushel shall be the weight per Winchester bushel as determined by the testing apparatus and the method of use thereof described in Bulletin No. 1065, dated May 18, 1922, issued by the United States Department of Agriculture, or as determined by any device and method which give equivalent results in the determination of test weight per bushel.

Foreign material.—Foreign material shall include all matter other than wheat which is not separated from the wheat in the proper determination of dockage, except that smut balls shall not be considered as foreign material.

Other grains.—Other grains shall include rye, oats, corn, grain sorghums, barley, hull-less barley, flaxseed, emmer, spelt, einkorn, Polish wheat, poulard wheat, cultivated buckwheat, and soybeans.

Damaged kernels.—Damaged kernels shall be kernels and pieces of kernels of wheat and other grains which are heat damaged, sprouted, frosted, badly ground damaged, badly weather damaged, or otherwise materially damaged.

Heat-damaged kernels.—Heat-damaged kernels shall be kernels and pieces of kernels of wheat and other grains which have been materially discolored and damaged by external heat or as a result of heating caused by fermentation.

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